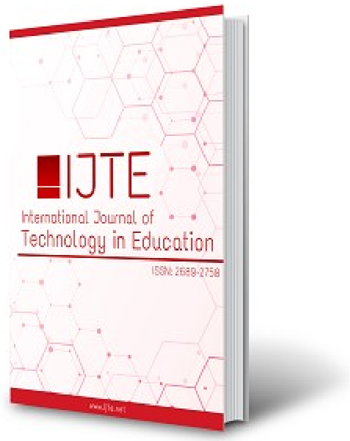

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STEM, iSTEM, and STEAM: What is next?

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Abstract

The historical and political emergence of STEM has changed the educational paradigm. Researchers, educators, and frontline professionals consider STEM as their savior. However, the ambiguity surrounding STEM and its successors, Integrated STEM education, and STEAM has created confusion for educators and frontline workers about which framework and concept they have to adapt to support their nation in the global financial crisis. Unfortunately, limited research offers insight into the historical, political, and educational development of STEM, iSTEM, and STEAM. This literature review fills this gap by addressing the historical, political, and educational development and uncertainty surrounding STEM, iSTEM, and STEAM. Also, the study explores the purpose, significance, and limitations of STEM, iSTEM, and STEAM individually and current pedagogical practices in this domain. Moreover, this literature review exposes the historical and current Canadian perspective of STEM, iSTEM and STEAM, and Canada's position and response to current global needs. Finding from the study reveal that there is a need for curriculum reform that involves adding STEM, iSTEM, STEAM domain and pedagogical practices in national/provincial curricula; professional development for teachers; support for the teachers and post-secondary institutions to increase STEM, iSTEM, STEAM-proficiency and their career interest among students to survive in the global economic race. Furthermore, the study highlights a need for further research and discussion about the STEM, iSTEM, STEAM domain and consensus among scholars on one platform. Moving forward, after STEM →iSTEM→ STEAM, What's next?

Introduction

Pre-World War II education was underfunded (Kuenzi, 2008); however, when the atomic bomb ended the war, it became clear that technology, and not necessarily the workforce, would be the key to winning the future conflict (Sanders, 2009; White, 2014). Consequently, education became a priority. This did not apply to all types of education, but specifically science, technology, engineering, and math (STEM) (Sanders, 2009; White, 2014). When the Soviet Union's scientists launched Sputnik in 1957 (National Aeronautics and Space Administration, 2008), the United States took the Sputnik effect seriously and promoted STEM educational reform, in addition to inestimable STEM industry advancements (White, 2014). Thus, STEM became a political movement. Similarly, the technologies associated with military advances translated to economic prosperity, STEM was soon seen as an economic movement (White, 2014). These political and economic priorities put significant pressure on educators to develop effective pedagogical approaches to promote higher STEM outcomes (Kuenzi, 2008; Sanders, 2009; White, 2014). Hence, policy-makers, politicians, educators, professionals, and other forefront military officials view it as an economic, political, and educational saviour resulting in the increased federal budget investment in STEM (Kuenzi, 2008).

Most recently, STEM has become a prominent educational movement (Kuenzi, 2008; Reiss & Holmen, 2007; Sanders, 2009), and researchers and educators are actively involved in developing new meanings and pedagogical frameworks. For example, Mobley (2015) defines STEM as an interdisciplinary method that connects other disciplines to solve real-life problems. However, Blackley and Howell (2015) note that STEM was initially perceived as an individual discipline emphasizing other fields, leaving engineering behind. Furthermore, STEM is relatively new to society, regardless of its philosophical roots dating back to 1958 (Daugherty, 2013).

Teachers, students, professionals, and researchers are attracted to STEM due to its enormous implications, such as improving life skills, career development to expanding the global economy. For instance, it enhances academic achievement, improves 21st-century skills, increases STEM field graduates, increases STEM personnel, increases students' interest in STEM, and improves the aptitude to provide understanding between STEM fields (NRC, 2014; Kanadlı, 2019). As a vital component of K-12 education in Canada, STEM offers countless benefits and presents various meanings and intentions in a wide range of educational professions and contextualize better educational outcomes (Shanahan et al., 2016).

The successful delivery of STEM is intrinsically linked to the teachers' perceptions, personal knowledge, and implementing that knowledge in their classroom practices (Bell, 2016) because their limited knowledge and understanding directly impact the student's success in the field. STEM develops a positive attitude of the students by providing at-risk students with many great opportunities and allowing them constructively to be lifelong learners. However, due to the differences between researchers on its meaning (Sanders, 2009) and lack of understanding of the STEM acronym among its professionals, the term "STEM" gets torn apart.

Consequently, Fall 2007developed a new framework of Integrated STEM (iSTEM- Integrated Science, technology, Engineering, Mathematics) which researchers propagated (Sanders, 2009). Besides, technology teachers realized that STEM had been marginalized as a technological education in the United States because of the ever-reducing funding options education (Sanders, 2009; Moore et al., 2014; Kelley & Knowles, 2016). Likewise, scholars defined the concept and the pedagogy of iSTEM in different ways. For example, Sanders and Wells (2006) defined iSTEM as a "technological/engineering design-based learning approach that intentionally integrates the concepts and practices of science and mathematics education with the concepts and practices of technology and engineering education" (p.2). Therefore, the technology teachers purposefully engage students in applying mathematics, science, and engineering concepts and practices to design and assess the authentic problem-solving methods (Sander, 2009). Nevertheless, the teachers' perception of implementing iSTEM in their classroom depends upon their years of teaching experience, knowledge of iSTEM, and teachers' interest in iSTEM activities.

Teachers believe that iSTEM education offers students opportunities to get involved in educational activities and success through problem-based and project-based learning (Havice et al., 2018). However, the argument and disagreement persist that there are connections between the disciplines when planning an iSTEM curriculum (Wells, 2006). Besides, the lack of creativity, innovation, and interest among college graduates has created a crisis and an issue of significant concern for policymakers across the globe (Kuenzi, 2008). The uncertainty and a dearth of consensus among the scholars on its definitions, frameworks and approach also contribute to the unsuccessful implementation of iSTEM education (Sanders, 2009; Moore et al., 2014; Kelley & Knowles, 2016).

Furthermore, scholars' confusion on the definitions and framework created a push to develop a new framework that amalgamates STEM and iSTEM requirements. This push led to STEAM (Science, Technology, Engineering, Arts and Mathematics) education development. In the STEAM platform, the Arts element has been purposefully added to integrated STEM education to develop creativity and innovative aspects (Land, 2013). Davidson (2016) explained that integrating liberal arts and the humanities component could add real worth to a student's curriculum if they are pursuing an engineering program. It is crucial to understand how teachers perceive STEAM to create a meaningful learning experience for their students. In STEAM lessons, the teachers can create a cross-curricular space by designing projects that nourish students holistically by engaging them in multiple disciplines and motivating them to transfer learning in multiple disciplines (Liao, 2016).

Gina Cherkowski, founder and CEO of Calgary-based STEM learning Lab, said that Canada lags behind other countries in executing STEM as an integrated approach for education (Davidson, 2016). While according to the Government of Canada (2018), Canada has soared as a world leader in many STEM fields, and several STEM-related jobs and several STEM career opportunities have emerged recently. Whereas the scholars are debating over STEM, iSTEM and STEAM approaches, concepts, and definitions (Gunn, J., 2017) that has created confusion among professionals which framework is better for their students to enhance their academic and career goals that drive their countries in a higher place in global economic competition.

This literature review offers a critical insight into this ambiguity and definitional crisis by providing the historical and political development of STEM and how its concept changed its meaning over time from STEM to iSTEM, and then STEAM. Regardless of the presence of many pieces of research allowing general overviews on various features of STEM (Holmegaard et al. 2014; Nugent et al. 2015), only a few of ideas holistically and critically analyze the insight of STEM and iSTEM. To the best of the author's knowledge, no previous research has investigated in-depth the political and historical development of STEM, iSTEM, and STEAM together. The limited study is available to address these sub-questions: How does the concept of STEM change its meaning over time from STEM to iSTEM, and then to STEAM? What is the current focus of STEM pedagogy?

This literature review also contributes to the broader interest by addressing uncertainty surrounding STEM, iSTEM, and STEAM that might be the reason for their unsuccessful implementation. This study fills this literature gap by examining the historical and political background and addresses the purpose, significance, and limitations of STEM, iSTEM, and STEAM individually. Moreover, the study explores pedagogical approaches to STEM, iSTEM, and STEAM. Furthermore, only a few studies have addressed STEM in Canada. This study will fill this substantial research gap by exploring the historical and current Canadian perspective of STEM, iSTEM and STEAM, and Canada's position and response to this global need.

Historical and Political Background of STEM

Even STEM is a result of several historical and political events, but its pedagogical approach has changed the educational landscape. The Morrill Act of 1862 was a prominent event that resulted in the development of land grant universities in US. Initially, these universities were focused on agricultural training, but soon they evolved strategy to market engineering-based training programs (White, 2011) within the mainstream education system. In 1880, a Harvard graduate, Calvin Woodward, was the first educator who promoted and investigated STEM by starting "Technology education" in the United States by placing the learning of mathematical concepts and practices in the context of wooden model exercises (Sanders, 2009).

Eighty years later, in 1957, the successful launch of the "Sputnik 1" by(then) the Soviet Union changed the political and technical landscape of the world, especially the United States (National Aeronautics and Space Administration, 2008). Sputnik precipitated the US establishment to implement STEM-led national defense policy in the United States; and in 1958, the National Aeronautics and Space Administration (NASA) promoted STEM Educational endeavors (White, 2011). Initially, the National Science Foundation (NSF) used the acronym SMET (science, mathematics, engineering, and technology), which was converted to STEM in 1990 (Sanders, 2009; Williams, 2011; Blackley & Howell, 2015).

In the US, STEM rhetoric originated in a political reaction to keep the US's global superiority in science and technology. While the UK's science, engineering and technology (SET) was the initial focus but gradually changed to STEM by 2006 (Blackley & Howell, 2015). According to Sainsbury (2007), "the best way for the UK to compete in an era of globalization, is to move into high-value goods, services, and industries. An effective science and innovation system is vital to achieving this objective" (p.3). Moreover, in Australia, there is a strong connection between the 1890s, 1930s, and 1980's economic depressions and advancement in technology education. 2007-2009's global financial crisis was a stimulating factor for the STEM education agenda (Williams, 2011). Since 1990, the European Commission has kept its primary focus on STEM policy. Likewise, the Asian countries such as Korea, Japan, China, which have a very competitive education system and rapidly growing economy (Blackley & Howell, 2015). These countries have developed broad national policies around science and technology and university and industry-focused research and development (Blackley & Howell, 2015). According to the report by Mobilizing Science and Technology to Canada's Advantage (2007); the government has established a strategy for science and technology research, including; expansion of national advantage (entrepreneurship, knowledge, and people); increasing investment of the private sector in science and technology; satisfying the public reputation of science and technology, and arrange to fund for science and technology students and researchers. Moreover, the Canadian policy is implemented through science and technology research funding agencies, including the Tri-Council Granting Agencies (Marginson, S. et al., 2013). Similarly, a unique Canadian Industrial Research & Development Internship Program involves three-way measures between universities, industry, and government to help world-class research, graduate research, and postdoctoral fellows (Marginson, S. et al., 2013). Moreover, this program adopts technology transfer between universities and industry (Marginson, S. et al., 2013).

Initially, the Western STEM agenda focused on vocational and economic goals (Williams, 2011), funded by the government and promoted by politicians (Blackley & Howell, 2015). They used several economic measures, shifts in workforce style, and economic crisis to rationalize it, resulting in an increased focus on STEM (Kuenzi, 2008; Williams, 2011 Most English-speaking countries, except Canada, reported 'STEM crises based on low performance in an international comparison of achievement and lower ranks than the nation expected to have; or decreased in STEM subject participation at school" (Marginson, Tytler, Freeman, & Roberts, 2013). While comparing both neighbouring countries, the rhetoric of global competitiveness and fright of national disaster has overcome the United States science education reforms. However, the Canadian reform has been driven by "science education, science teaching, and scientific practice communities" and not by economic imperatives (Shanahan, Burke and Francis, 2016, p. 133). Unfortunately, though, one cannot say that political and economic fear do not scare the Canadian STEM education researchers and educators; but they do not creep these frightening goings-on into dominating the national STEM discussion and reform, let alone policy.

Several international organizations such as the Organization for Economic Cooperation and Development (OECD), the World Bank, United Nations Science, Education and Cultural Organization (UNESCO), the European Union (EU), and the International Association of the Evaluation of Educational Achievement (IEA), pay special attention to STEM policy as a global focus (Marginson et al., 2013; Blackley & Howell, 2015).

STEM Definition

The researchers have devised many definitions, meaning, and explanations to STEM, depending upon their perspectives and a given context. Some researchers have tried to integrate some or all of the fields of science, technology, engineering, and mathematics, or some unit or course, contingent to the connection between the content and real-life problems (Moore et al., 2014). Some researchers describe STEM as a method to explore the learning and teaching among two or more STEM domains or between STEM domains and other courses (Sanders, 2009). However, Bell (2016) describes STEM as an acronym that describes the study of science, technology, engineering, and mathematics (STEM). Ramely (2011) perceived STEM as developing coherently, not integrated, curriculum, in which science and mathematics serve as 'bookends' for technology and engineering. However, this concept has not entirely been put to practice. According to Kelly and Knowles (2016), STEM is an approach to teach two or more STEM domain content to the students in the application that connects science, technology, mathematics, and engineering in contexts related to real-life problems to enhance their learning experiences.

According to Tsupros, Kohler, and Hallinen (2009), "STEM education is an interdisciplinary approach to learning, in which rigorous academic concepts are coupled with real-world lessons as students apply science, technology, engineering, and mathematics in contexts that make connections between school, community, work, and the global enterprise, enabling the development of STEM literacy and with it the ability to compete in the new economy." STEM-literacy refers to the understanding of the "nature of science, technology, engineering, and mathematics and the familiarity with some of the fundamental concepts from each discipline, which should be an educational priority for all students" (Bybee, 2010; National Academy of Engineering and National Research Council, 2014).

Though these definitions provide a diverse meaning but still share some common grounds, for instance; (i) it involves an application that relates to at least two of the science, technology, mathematics and engineering fields, (ii) these fields are brought together in a context based on real-life problems, and (iii) it helps to teach students the subject-matters or enriches their learning (Kanadlı, S., 2019, p.960; Moore et al., 2014; Kelly and Knowles, 2016).

Purpose of STEM

The concept of STEM created a motivation for educational reform, and educators supported it. At the same time, the teachers were concerned mostly with the growing numbers of student enrolments in their programs (Sanders, 2009). Arguably, STEM has been considered as a way to prevent or avoid an economic crisis in the future, such as the Global financial crisis; however, these assumptions were baseless without any evidence (Williams, 2011). Although it was developed from non-educational, political rationale and then imposed upon educators to endorse later in the 2000s, many UK and US collaborative education projects grew and received significant findings (Kuenzi, 2008; Pitt, 2009). They naïvely reasoned to increase the engineers' and scientists' pool and maintain global economic dominance by emphasizing education in the science, technology, engineering, and mathematics STEM disciplines (Blackley & Howell, 2015).

STEM would not succeed before elucidating and developing its primary purpose in the school program. STEM addresses the conceptual and technical skills and abilities of the professional dealing with STEM-related personal, social, and global issues (Bybee, 2010). Bybee (2010) described that STEM creates the understanding of STEM disciplines as a human effort that contains the process of inquiry, design, and analysis to recognize how STEM forms our physical, intellectual and social world. Moreover, "engaging in STEM-related issues and with the ideas of science, technology, engineering and mathematics as a concerned, effective and constructed citizen" (Bybee, 2010, p. 31) supports the 21st century STEM vision.

The STEM education reform was targeting three main goals: 1. “Increase the number of students pursuing higher degrees and careers in STEM; 2. Enlarge the participation in the STEM workforce, and 3. STEM literacy for all” (National Research Council, 2011). The National Governors Association’s (NGA) Innovation America: Building a Science, Technology, Engineering, and Math (STEM) agenda, described STEM as follows:

> STEM literacy is an interdisciplinary area of study that bridges the four areas of science, technology, engineering, and mathematics. STEM literacy does not simply mean achieving literacy in these four strands or silos. Consequently, a STEM classroom shifts students away from learning discrete bits and pieces of the phenomenon and rote procedures and towards investigating and questioning the interrelated facets of the world (NGA, 2007).

Significance of STEM

STEM has captured the attention of students, professionals, and researchers due to its great significance, from improving life skills, career development to expanding the globalized economy to name only a few.

Many longitudinal studies have revealed that, STEM enhances students learning and student's achievement in STEM fields in the school programs; for instance, it enhances academic achievement; it improves 21st-century skillset; it accelerates STEM field graduates' understanding around critical life science topics; it increases STEM personnel; Increase students' interest in STEM; improve the aptitude to provide understanding between STEM fields (Stohlmann et al., 2012; NRC, 2014; Kanadlı, 2019). Siregar, Rosli, Maat, and Capraro (2019) analyzed together with the impact of STEM programs on student's mathematics achievement. The researchers find the positive effects of STEM programs on student's achievement.

While focusing on life skills, STEM develops "analytical thinking, decision-making, creative thinking, entrepreneurship, communication and teamwork" (Kanadlı, 2019, p.970). Several other benefits of STEM include 21st-century skills such as creativity and innovative thinking, critical thinking, problem-solving, decision making, self-reliance, logical thinking, technological literacy, metacognition, communication, teamwork, literacy of information communication technologies and integration into the world (Stohlmann et al., 2012, Çepni & Ormancı, 2018; Kanadlı, S., 2019). Stehle et al. (2019) revealed that secondary school lesson plans demonstrated higher levels of 21st Century skills, especially for grades 11 and 12. Besides, the STEM helps in the development of the psychomotor, scientific process, engineering, design, inquiry, imagination and 21st-century skills or some of the life skills such as critical thinking, teamwork, creativity, and innovative thinking, literacy of information communication technologies, decision making, metacognition, communication, problem-solving, and integration into the world (Yıldırım, 2016; Çepni & Ormancı, 2018; Kanadlı, S., 2019). According to Ontario (2016), these are crucial skills to develop the cognition, personal, and interpersonal characteristics of a person and help them understand their potential to solve complex real-life problems.

According to Baharin et al. (2018), the STEM approach can enhance thinking skills among students. While focusing on integrating Science, Technology, Engineering and Mathematics (STEM) in the educational curriculum in Malaysian schools, researchers believed that the 21st-century teaching and learning approach to STEM is one of the keys to effective learning, meaningful and deep understanding that can integrate science, technology, engineering and mathematics among students (Baharin et al., 2018).

STEM attracts the student's attention and increases their motivation, interest, curiosity, and desire to learn. Likewise, STEM increases self-confidence and develops a positive attitude of the students towards their learning to support their future careers in STEM fields (Koszalka, Wu, & Davidson, 2007; Nite et al. 2017; Kanadlı, S., 2019). Similarly, it "provides opportunities for students to explore traditional subject areas by working on authentic, engaging real-world projects and create more opportunities for innovative thinking, collaboration, and creativity" (Davidson, 2016, p. 2)

For educators, STEM increases their field knowledge and increases the desire to adopt the STEM profession (Nite et al., 2017). STEM helps to improve teacher's STEM-related pedagogical content knowledge, and they learn to use instructional strategies that engage the student in their own learning process by using scientific inquiry, engineering design (Kanadlı, S., 2019). STEM offers several benefits to society, including advanced drugs, safe structures, effective forms of transportation, convenient apps, innovative style workplace, and organization (Davidson, 2016).

STEM Limitations

With all the benefits and significance, STEM created confusion among the researchers and educators about the acronym STEM from the beginning, who consider it as a separate subject as well as and disconnected discipline (Abell & Lederman, 2007; Sanders, 2009; Wang et al., 2011), that made its implementation challenging.

Regardless of the resources and money poured into STEM, the success rate was little (Breiner et al., 2012; Kuenzi, 2008; Blackley & Howell, 2015). Due to the STEM curriculum's defective design, the students and community members believe that the STEM program is not designed for all; instead, it has developed only for interested or academically high achievers making it an issue for inclusive design. They also believe that STEM strengthens math and science education and leave behind less interested students (National Commission on Mathematics and Science, 2000) and excludes technology and engineering at a school program. Likewise, teachers use their traditional teaching of science and mathematics and almost ignored the technology and engineering component of STEM (Moore & Smith, 2014).

Despite aforesaid educational attention and benefits, studies reveal several limitations of STEM from the government agenda to implementation and student achievement. STEM activities take time to prepare, and a lot of resources and skills are needed to create and implement these activities (Kanadlı, 2019; Kelley & Knowles, 2016). Teachers believe that creating STEM activities puts an extra burden on them. Also, sufficient material and resources are needed to perform STEM activities that are expensive and create an extra burden on schools. Similarly, STEM activities are hard to develop and apply in crowded classes (Kanadlı, 2019). In addition, a specialized or skilled professional is required to deliver the STEM activities. Due to the absence of a clearly defined STEM curriculum document to guide, the teachers perceive and teach STEM as an individual subject instead of one subject (Blackley & Howell, 2015; Kanadlı, S., 2019).

Science literacy skills support STEM education (Rokayah et al., 2019). The students rely on both compulsory textbooks and STEM resources as a source of scientific literacy. However, science skills and STEM literacy skills need more attention, and teacher needs more to apply appropriate STEM learning strategies based on authentic children's data and social literacy (Rokayah et al., 2019).

Furthermore, these problems have made STEM almost unapproachable for a socially disadvantaged population. Bozkurt Altan & Köroğlu, 2019 drew attention to the incompetency of STEM fields to social injustices and how we can implement STEM in a social justice framework. The study suggested a need for professional development for teachers in STEM education and also the development of action plans for disadvantaged groups by STEM-educated teachers (Bozkurt et al., 2019). Furthermore, the research emphasizes the funding for future STEM education research and STEM-focused activities for disadvantaged groups (Bozkurt et al., 2019) so they can enjoy the benefits of STEM education. Yet numerous studies have indicated a lack of interest and motivation among students towards STEM fields or 'STEM pipeline' created a global concern (Sanders, 2009; Kelley & Knowles, 2016) that require the researcher and developers to look deeply into the STEM framework to find and solve the STEM-related problem. To meet the global challenges, many countries are showing their concern for STEM improvement as the need for STEM skilled professionals increasing (English 2016; Marginson et al. 2013). Also, determined by the current and future need for the STEM professional shortage, the researchers and policymakers are looking for new educational reform. Baharin et l. (2018) persuaded that the approach of STEM education should include elements of problem-solving, critical thinking, creative thinking, and scientific thinking that can enhance higher-order thinking skills (HOTS) among students, which needs more experienced STEM educators.

Regardless of the aforesaid educational attentions, there is a central government agenda that focuses on fulfilling labor demand and encouraging business innovation. Funding was poured from all sides to support STEM (DeCoito et al., 2016). Yet, many unanswered questions need consideration; for instance, it is still not clear what exactly the purpose of STEM is? Are we educating our children aiming that they improve wisdom, knowledge and become active citizens? Do we perceive education as a way to prepare a workforce that is prepared to innovate and compete globally? (DeCoito et al., 2016).

Emergence of Integrated STEM (iSTEM) Education

As mentioned above, the educators and researchers realized the inevitable ambiguity of STEM. They looked for the framework or model that accommodates the need for science, technology, engineering, and maths in an integrated way. Besides, the technology educators feared that STEM had marginalized technology education in the United States; as a result, funding for technology education has been reduced; besides, another new funding stream generated for science and mathematics education. In September 2005, the Technology education faculty at Virginia Tech launched an innovative STEM graduate program that focused on integrating and investigating new approaches to STEM and intentionally situated the teaching and learning of science and mathematics in technological/engineering designed-based pedagogical activities (Sanders & Wells, 2005; Sanders, 2006).

iSTEM Definition

According to Sanders (2009), the concept of iSTEM contains the approach that "explore teaching and learning between/ among any two or more of the STEM subject areas, and/or between a STEM subject and one or more other school subjects" (p.2). iSTEM offers a technology-rich science and math program that can discover engineering disciplines and incorporate other subjects such as language arts, social studies, and arts to improve their learning.

While Moore et al. (2014) explained the iSTEM as "an effort to combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems" (p. 38), these definitions explain the researcher's perceptions of iSTEM but also provide deep insight into pedagogical approaches and curriculum design as well. According to Sanders (2009), the iSTEM pedagogy or "purposeful design and inquiry" (PD&I) technological design has intentionally been integrated with the scientific inquiry; that engages learners or groups of learners in scientific inquiry positioned in the context where learners solve real-life problems in a technological, productive robust learning environment.

Purpose of iSTEM

The iSTEM was launched to give attention to the technology education program and includes the instructional technologies essential to designing, creating, and engineering only. Whereas the purpose of iSTEM was to provide a fresh approach and investigate those new approaches to integrate STEM concepts and practices in technological/engineering design-based pedagogy (Sanders, 2009). The iSTEM offers the approach that explores teaching and learning between two or more STEM or other school subjects. It purposefully integrates "technological design with scientific inquiry, engaging students to teams of students in scientific inquiry situated in the context of technological problem-solving-a- robust learning environment" (Sanders, 2009, p.21). iSTEM educators explore and device integrative replacements to traditional and disconnected STEM subjects (Sanders, 2009). iSTEM education is more than an integrated curriculum, but also "an instructional approach integrating the teaching of the four subjects of STEM using scientific inquiry, engineering and engineering design, mathematical thinking and reasoning, and 21st-century interdisciplinary themes and skills" (Bryan, Moore, Johnson, & Roehrig, 2015).

Significance of iSTEM

iSTEM is an innovative instructional approach that offers many benefits to technology education students, teachers, and researchers as well. iSTEM pedagogy emphasizes design experiments that allow researchers to investigate in-depth the theory and guesses about its framework. Also, it allows researchers to investigate how teaching science and mathematics in the culture of technological/engineering design motivates and increases student's interest and understanding in all STEM disciplines (Sanders, 2009). Kelly and Knowles (2016) believe that iSTEM connects engineering design, scientific inquiry, technological literacy, and mathematical thinking as an integrated system with the STEM community of practice.

iSTEM actively involves students in engineering design challenges to learn about engineering design and engineering practices and deepen their understanding of core ideas of the content (Hernandez et al., 2013). Engineering design activities not only strengthen students' knowledge of science, technology, engineering and mathematics but also bring factual content knowledge, abstract knowledge and application closer (Riskowski et al., 2009). A case study on iSTEM course of "at-risk and/or non-college-bound students found that iSTEM increase students' motivation, reduce their school absences compared with previous years, and enhance students' self-esteem (Wicklein & Shell, 1995) because iSTEM teachers "demonstrate deep and flexible subject matter knowledge, pedagogical content knowledge connected to the STEM education disciplines and skills to integrate contents" (Bryan et al., 2015). Clark et al. (2006) recognizes technology education as a critical driving force for the successful integration of STEM subjects. Research indicates that a "positive relationship between students' academic achievement in mathematics and technology-based instructions result in producing a positive attitude towards subjects studied and enhance students' self-efficacy (Longnecker, n.d.).

iSTEM provides opportunities for students to involve in educational activities and achievement by problem-based and project-based learning (Havice et al., 2018). It allows students to explore and engage in real-world problems while improving their multi-disciplinary skills in a small collaborative learning environment. Moreover, some researchers and educators claim that the iSTEM method prepares students for a global market in a purposeful way (Chute, 2009; Daugherty, 2013; Sanders, 2012). The problem-based approach connects students with the real world and its problems; otherwise, they may completely get disconnected from the real world and the global market.

Integrating mathematics and science instructions in iSTEM leads to higher achievement scores in those subjects' assessments (Hurley, 2001; Lehrer & Schauble, 2006). However, the introduction of engineering instruction in iSTEM shows a mixed reaction to achievement improvement (Tran & Nathan, 2010). Science and mathematics assessment can relate to the iSTEM pedagogy. That's why teaching and learning these subjects in a non-traditional way motivates students and increases interest in these subjects. While introducing engineering with well-defined instructional methods of math and science may complicate learning for students that reflect on their achievement.

Limitations of iSTEM

Like every approach, there are many limitations to teaching iSTEM. iSTEM emphasizes career-related fields with a focus on STEM practices and authentic STEM knowledge applications (Kelley & Knowles, 2016). Also, making cross-connections in content is complex. It needs specialized skilled teachers who teach STEM content intentionally in a way that helps students in understanding how to apply STEM knowledge in solving real-world problems. Moreover, teaching STEM from the iSTEM approach limits, the content taught (Kelley & Knowles, 2016) because it is not possible to integrate all STEM curriculum fully. Some specific topics and concepts have much importance and require their specific way to teach. For instance, some crucial concepts in science and mathematics are theoretically focused and are unable to provide authentic applications for engineering design. Students' STEM skills and abilities influence the STEM integration lesson design of the teacher. Also, based on problem-solving, application engineering design, life skills, and connections, teachers consider science and engineering as a significant aspect, while mathematics and technology secondary aspects of STEM integrations (Wang et al., 2012).

Notably, the integration of STEM subjects cannot be effective without a strategic approach to implementation. Moreover, to build a strategic approach to integrated STEM education needs a strong conceptual and theoretical understanding of how to teach students and implement STEM content (Kelley & Knowles, 2016). This complex process requires the researcher to look for the available frameworks that not only have implemented STEM content and pedagogy in an integrated way but also what type of professional development teachers is needed to implement that integrated framework successfully. One of the most important limitations is that iSTEM activities are designed for small groups that are inappropriate or not suitable for the usual large, crowded class. Like STEM, iSTEM activities need a lot of resources, time, and effort to design and successfully implement in a classroom. Today's secondary education in the US, Canada and other countries silo STEM subjects within their specific structure of departmental agendas, requirements, specific content standards, and end-of-year examination (Kelley & Knowles, 2016). These barriers limit the successful implementation of iSTEM.

Emergence of STEAM Education

In the global S.T.E.M. competition, when S.T.E.M. students from other countries such as Singapore, China, Germany, and the U.K. are growing, but only 4.4% of US-born face a low registration in undergraduate programs who are enrolled in S.T.E.M. programs in1(Land, 2013). The international comparison "Program for International Student Assessment (P.I.S.A.)" reveals that Taiwan, the Shanghai region of China, Korea, Singapore, Finland, Hong Kong, and Canada have significantly smaller groups of under-performers" in scientific and mathematical literacy in P.I.S.A. (Marginson et al., 2013). However, the United States ranked 38th out of 71 countries in mathematics and 24th in science (Gunn, 2020). Lack of creativity and innovation in recent college graduates in the United States created a push for STEAM education that believes to increase interest and motivation in S.T.E.M. fields but also create qualified future leaders. John Maeda, former president of the Rhode Island School of Design, supported the movement from S.T.E.M. to STEAM by adding "Arts" to S.T.E.M. and brought the initiative to the leading policymakers by arguing that design thinking and creativity are crucial elements for innovation (Liao, 2016). Later the bill was introduced in the U.S. Congress to allow for funding for STEAM education from President Obama Administration as a S.T.E.M. funding initiative (Beaman & Sears, 2013).

Later, Georgette Yakman, a scholar at Virginia Tech University, formalized the STEAM concept but did not get support in the U.S. Ultimately, she started working with the South Korean government, who not only recognized her work but eagerly adopted it as a national education reform (Liao, 2016). She claimed that adding the arts subjects to the acronym S.T.E.M. helps to connect the subjects but also contributes to the global socioeconomic world (Setiawan & Saputri, 2019).

STEAM Definition

Like other STEM fields, many definitions and explanations came forward for STEAM education as well. Yakman (2008) explained STEAM education as "the traditional academic subjects (silos) can be structured into a framework by which to plan integrative curricula" (p.1). Meanwhile, she defined the STEAM education as "Science and Technology, interpreted through Engineering and the Arts, all based in a language of mathematics (Yakman, 2008, p.1).

Silverstein and Layne (2010) provide another definition of STEAM education. They maintained that it is "an approach to teaching in which students construct and demonstrate understanding through an art form. Students engage in a creative process that connects an art form and another subject area and meet evolving objectives in both" (p.1). The researchers emphasized creative productions and encouraged hands-on learning through art-making (Liao, 2016).

The art component in STEAM is connected with "expressiveness, evoking emotion, generating empathic understanding, stimulating imagination that disrupts habits of mind and creates open-mindedness, and eliciting emotional awareness" (Eisner, 2008). Bucheli, Goldberg, and Philips (1991) provide a succinct account to define art as education for sustainability with an altruistic goal that helps to discover our humanity.

Purpose of STEAM

From the beginning, the STEAM education intended to classify all areas of study into a framework that would help students to understand the importance of the connections between the fields and acquire skills in all areas to become well-rounded citizens (Yakman, 2008). The other goal was to provide academia with a framework that helps them to organize the teaching in that field in an interconnected way with one another in a real-world way that would be reflected in the educational settings (Yakman, 2008). These frameworks break the boundaries of individual subjects when taught in a universal integrated approach by supporting problem-based learning and highlight the pragmatic and real-world connection. Yet, it may increase the workload of the teachers and weaken the curriculum lucidity.

Moreover, STEAM education aims to promote the cognitive development of the students and also encourages their emotional and spiritual realm, increase their critical thinking and problem-solving skills and inculcate creativity (Setiawan & Saputri, 2019). Also, the purpose of teaching creative design thinking skills is to motivate students to become innovators, independent learners, inspire them to feel the joy of learning by connecting content to their individual learning experiences (Park et al., 2016). Furthermore, the Addition of arts helps the learners to demonstrate their creativity, effectiveness, and financial and artistic sense to solve real-world problems.

Significance of STEAM

The contextual integration approach to STEM education in STEAM education has several benefits because it covers a wide range of fields and interests of individuals, organizations, and nations. STEAM education reinforces a constructivist pedagogy, student-centered authentic learning (Pitt, 2009). The STEAM activities involve students in their own learning process and develop 21st-century skills necessary to adopt in the global competency.

The STEAM program strengthens creativity and encourages students to innovate and experiment with new things (Charters, 2017). Park et al. (2016) revealed that the majority of Korean teachers, especially experienced male teachers, had a positive view of the role of STEAM education and its impact on students' interests and learning. Moreover, creative problem-solving is a centerpiece of STEAM education through art-making. The students learn by problem-solving in a given project, which encourages them to see the connection among their knowledge, skills, and capabilities that are eventually connected to 21st-century problems (Liao, 2016). Furthermore, STEAM education generates a cross-curricular space that cannot be seen in traditional individual fields (Liao, 2016). These spaces are created when students learn without dividing subjects individually; instead, they view their creativity by engaging in and beyond these subject boundaries.

From the teaching point of view, STEAM education serves as a stimulant for helping teachers and students to come out of their subject limits into creative cross- disciplines (Pitt, 2009). Also, the visual representation of complicated subjects helps the students to visualize and conceptualize new ideas. Through STEAM lessons, teachers can design creative assignments with cross-curricular connections and nourish their student's skills in multiple disciplines. For researchers, science disciplines have realized that adding visual arts to the research helps them to formulate different research questions that can guide them to more thorough solutions to the world's complex problems (Beaman & Sears, 2013). The visual arts element of STEAM education helps the researchers encourage technological innovation by the demands of their own creative vision (Beaman & Sears, 2013).

For engineering students, the liberal arts and humanities components add value to the curriculum (Davidson, 2016). They can view their program not as a disconnected entity instead help them to investigate the engineering behind each aesthetic element. In 2015, M.G.A. Entertainment established the official National STEM/STEAM Day that is celebrated on November 8th every year (Schonberg et al., 2017). According to Isaac Larian, C.E.O. of M.G.A. Entertainment, "We want to show children that STEM and STEAM are already all around them and that their favorite hobbies are actually rooted in science, technology, engineering, art and math" (Schonberg et al., 2017). Initial studies on pioneering STEAM curricula in the United States recognized that integrating science, technology and the arts successfully in learning activities involved marginal and social disadvantage students, which results in enhancing their improved literacy and numeracy skills (Clark, 2014; Reddy & Rahman, 2015). Integrating stories about everyday ethical dilemmas into Earth Science lessons revealed that at-risk students were successfully involved in ethical decision-making while developing their scientific knowledge and inquiry skills in science/mathematics classes (Taylor, Taylor, & Chow, 2013).

While highlighting the significance of STEAM, Taylor (2016) emphasis that:

- STEAM enhances and expands the scope of STEM and is not in opposition to it.
- As a curriculum philosophy, STEAM allows science teachers to involve in school-based curriculum development.
- STEAM engages teachers in developing a human-centred vision of 21st-century education and their role as educators.
- It provides a creative design space for educators in various learning fields to collaborate in creating integrated STEAM curricula.
- STEAM activities can be designed and implemented by an individual teacher on a moderate scale.
- STEAM educators can design activities inspired by project-based learning programs (for example, Holm, 2011).
- STEAM involves students in transformative practices based on five interrelated ways of knowing: "cultural self-knowing, relational knowing, critical knowing, visionary and ethical knowing, knowing in action" (Taylor, 2015).

Limitations of STEAM

Despite many efforts to make STEAM education and its framework successful, it offers many limitations. STEAM lessons can be implemented more efficiently in the elementary curriculum because there is less pressure on students and teachers for test pressure than in secondary schools (Park et al., 2016). Also, the secondary school curriculum and lessons are designed to prepare students for the college entrance exams, and it would be difficult for the teachers to create and conduct STEAM lessons and prepare students for the exams as well. Moreover, the elementary teacher's education program prepares teachers to teach all subjects (Park et al., 2016); that's why creating an integrated lesson won't be a challenge for them. However, the secondary school teachers' program prepares teachers to teach one specialized subject. Choi, Lim, & Son (2017) believe that it is hard for students to find a meaningful image due to the lack of learning experience in combined knowledge. Furthermore, there is a need to provide meaningful learning support for the students in the STEAM programs (Choi et al., 2017).

Just like STEM, and iSTEM, creating, designing, and implementing STEAM activities needs a lot of time, money and resources. Extra funding is required to perform STEAM activities at schools. Moreover, STEAM education has no specified curriculum, so it would create extra work for the teachers to design cross-curricular activities. Meanwhile, with the regular school schedule, the STEAM activities are performed mostly in science classes. So, there is a need for scheduling special STEAM classes in a regular timetable (Park et al., 2016).

Pedagogy around STEM, iSTEM, and STEAM

STEM, iSTEM, and STEAM frameworks share similar pedagogical approaches in teaching and learning; therefore, the umbrella term STEM is used in this paper to provide clarity and simplicity of the content. The primary objective of any pedagogy is to support learners towards achieving a learning outcome, whether it is cognitive, behavioral, or both. The pedagogical practices defined by educators and researchers for successful designing, and implementing STEM education, are not new to the classroom teachers as these pedagogies are already in practice in regular classrooms. However, when these pedagogies take a new turn by integrating STEM disciplines successfully and effectively, teachers perceive that STEM pedagogy requires some fundamental shifts in establishing classroom environments to teach. For some teachers, these changes are not always motivating and challenging, inhibiting their integration in the classroom. Educators use a variety of pedagogical approaches to create a thriving STEM learning environment.

Zemelman, Daniels, and Hyde (2005) provide insight into the ten best STEM pedagogical practices for successful integration of STEM disciplines. There are as follows; (1) using manipulatives and hands-on learning; (2) cooperative learning; (3) discussion and inquiry; (4) questioning and conjectures; (5) using the justification of thinking; (6) writing for reflection and problem solving; (7) using a problem-solving approach; (8) integrating technology; (9) teacher as a facilitator approach; (10) using assessment as a part of instruction. Moreover, these approaches support a teacher's pedagogy by focusing on making connections, representations and deal with misconceptions. Also, it helps the teachers to focus on big ideas that are connected or interconnected between subjects (Walker, 2007).

The STEM pedagogy drives beyond demonstration; it motivates critical thinking, performing, and risk-taking within a thoughtfully designed learning environment, where students confidently apply their knowledge and understanding (Bell, D., 2016). In STEM, project-based and problem-based learning, inquiry-based teaching, argumentation, and digital learning, is used to achieve pedagogical innovation (Baharin et al., 2018). Project-based and problem-based learning motivates students to discover a new solution to the problems, discover new possibilities, create their interest in STEM subjects, and enable them to achieve their goals in an energetic and a fun way. Problem-based instructions use real-world problems to tie with an engaging and motivating context (Thibaut et al., 2018). This student-centered approach encourages active learning and supports the use of authentic, real-world problems (Ashgar et al., 2012). Problem-based learning in STEM aims to develop problem-solving skills in the students by providing a realistic self-directed problem-solving process. Teachers serve as a facilitator and support the students when student need them to achieve their goal (Ashgar et al., 2012). The problem-based, project-based instructions in STEM provide an authentic, open-ended, ill-structured, real-world problem to the students that resemble challenges faced by engineers and scientists in the workplace and allow for multiple ways to solve and answers (Ashgar et al., 2012).

Of lately, inquiry-based teaching and learning are considered a key to the success of STEM pedagogical practice. In STEM scientific inquiry, the students define their daily problems, formulate questions, and answer it through investigation before they get to engage in the engineering design process to solve problems (Kennedy et al., 2014). Inquiry-based pedagogy intentionally promotes experiential learning to promote knowledge construction (Wells, 2016) in STEM, where students are encouraged to test their prior knowledge, predict, observe and record their explanations (Thibaut et al., 2018). However, truly authentic inquiry might be challenging for STEM high school students due to their lack of experience, knowledge and understanding of STEM-related content (Thibaut et al., 2018). Students need an appropriate amount of guidance to help achieve their desired conceptual change. Therefore, teachers need to provide support to the students by asking questions to help them discover the problems in their reasoning and research design to find the ultimate solution (Thibaut et al., 2018).

In collaborative learning, students design their own group work, even without getting proper training in small-group social skills. The teacher serves as a facilitator, not monitor, and refers students back to their questions so they would resolve team conflicts on their own (Matthews, 1995). While in cooperative learning, the teacher serves as an observer and facilitator and intervenes when needed. Moreover, students get training in small-group social skills, and teachers motivate students to evaluate their group performance in order to improve their performance and participation level (Matthews, 1995).

Guzey et al. (2016) emphasize providing multiple opportunities and sufficient time to get involved in teamwork, so they can practice and improve their teamwork skills. To achieve that, students need to be motivated to connect science concepts, mathematical and engineering thinking through reading, writing, listening and speaking (Stohlmann et al., 2011). Integrated STEM activities encourage the student-centered approach because it helps students to develop better understanding and skills by actively involving them in their own learning process (Guzey et al., 2016). However, teachers need to provide specific guidelines to implement these student-centered activities. The use of hands-on activities and manipulatives provides fewer restrictions and actively involves students in their learning (Thibaut et al., 2018). It allows students to witness the role of innovation in everyday life (Clark / Ernst, 2007). 21st-century skills refer to the knowledge, skills, and characteristic traits that are deemed essential to work successfully as citizens, workers, and leaders in the 21st-century workplace (Bryan et al., 2015) as these places need creativity and innovation, critical thinking, problem-solving, communication and collaboration.

Teachers found it challenging to implement student-led instructions and move away from traditional teacher led-instructions (Lesseig et al., 2016; Park et al., 2017). The teachers also showed their concern about their pedagogy that needs to be aligned with STEM curriculum philosophy and pedagogy, which they found unmanageably overwhelming (Holstein & Keene, 2013). The research on the effects of inquiry-based iSTEM on 4th-grade student's attitudes towards science education revealed a positive attitude of the students towards science literacy (Toma & Greca, 2018). However, teachers show their reluctant attitude towards using inquiry-based learning in iSTEM due to its directive and demanding educational model (Toma et al., 2018). The teachers voiced their worries about non-inclusive STEM pedagogy that cannot meet the needs of diverse learners in their classrooms, especially students with disabilities and various cognitive challenges (Park et al., 2017). Moreover, the secondary school teachers showed their concerns about the subject-specific instructions, such as the direct instruction of science and mathematics content (Dare et al., 2014). However, the elementary and middle school teachers showed no concerns about that.

In STEM argumentation, the students participate in scientific discussion, make claims based on facts, defend and support their claims, and justify the conditions under which their claim will be evaluated (Toulmin, 1958). Whereas in digital learning, students use their digital tools and mobile devices such as mobile phones, tablets, laptops, notebooks, and other digital learning tools in the learning process to implement STEM educational experiences.

Furthermore, these STEM pedagogical approaches help teachers to design activities that are; built on students' prior knowledge, helped students organize knowledge around critical ideas, concepts or themes; also allowed students develop students understanding of how to interconnect various concepts and processes; and support students to understand what, how and where the knowledge is situated in a specific context. The teachers can use a student-centered strategy to implement these pedagogical approaches in STEM classes successfully. For the successful implementation of STEM, it is crucial to make the connection between various STEM subjects (Thibaut et al., 2018) because without any guidance; students are unable to spontaneously integrate concepts across different representations and content on their own (Pearson, 2017). Therefore, deliberate and explicit support should be provided to assist students in building knowledge and skills across STEM content (Pearson, 2017). However, emphasis should be put on a meaningful and purposeful integration, not merely on a mere integration. Moreover, integration of STEM content should focus on learning goals and objectives in the individual STEM disciplines and provide sufficient content knowledge of the relevant concepts in each subject to the student (Pearson, 2017).

iSTEM is an innovative design-based pedagogy that relies on technology teachers. The technology teacher purposefully engages students in applying mathematics, science, and engineering concepts and practices in making, designing, and assessing the authentic problem-solving method (Sander, 2009). Furthermore, fulfilling the current need and demand requires more iSTEM-led classes in schools and universities and upscale the professional development for the teachers in STEM pedagogy and integration of technology in the classroom (Davidson, 2016). The effective design challenges in iSTEM should be “open-ended, authentic, hands-on and multidisciplinary” (Shahali et al., 2016). These challenges provide industry-related problems to enable students to explore and create various technologies that need them to work with insufficient information and to consider difficulties, safety, risks and alternate explanations (Guzey et al., 2016).

In STEAM lessons, the teacher can create a cross-curricular space by designing projects that nurture students by engaging them in multiple disciplines and motivates them to transfer learning into multiple disciplines (Liao, 2016). Student’s engagement, reflection, and skill to explain the suggestion of the project, and apply their knowledge, understanding, and skills to a new discipline, enable students to connect their work to the real world (Liao, 2016).

From the beginning of 1983, Howard Gardner's research on multiple intelligences had a significant effect on thinking and practice in education. The multiple intelligence theory had highly impacted instructional practices by providing platforms to cater to the diverse needs of learners and it suggested alternate routes to STEM instructional pedagogy (Sulaiman & Sulaiman, 2010).

Exceptional instruction involves deep content and through pedagogical knowledge to positively influence students. STEM pedagogy relies on teacher's pedagogical knowledge and content knowledge of STEM and related disciplines. Also, the teachers must have deep knowledge and understanding of science, technology, engineering and mathematics content to effectively implement iSTEM in the classroom. Moreover, they must have the pedagogical content knowledge to teach STEM content to the students (Shulman, 1987); if a teacher lacks content knowledge of STEM subjects individually, then how he/she would be able to implement the STEM content successfully? Moreover, if someone asks a secondary school art teacher or science teacher to teach other subjects, it creates a knowledge gap and a new challenge for the teacher, student, and, at large, to society. Bell, D. (2016) conducted the study to explore the ways teachers of design and technology perceive STEM and how the range in variation of perception relates to design and technology pedagogy. The researcher revealed that teacher's perception of STEM, their personal knowledge, and understanding of that knowledge are intrinsically linked to the effectiveness of STEM delivery in their own classroom practice.

Teachers believe that administrative support from the school, board and ministry is crucial for successful implementation of STEM in their classrooms because STEM activities are expensive and need many classroom resources, technological resources, time and funding to plan, design and implement (Park et al., 2016). Teachers believe that it is necessary to have the flexibility to expand the curricula to meet students' interests, talents and academic needs (Park et al., 2016). Likewise, they need flexibility in their schedule and less workload because they believe that planning and implementing these activities will increase their workload (Margot & Kettler, 2019). Although the STEM, iSTEM and STEAM are still in infancy, the effective implementation of appropriate pedagogical practices can make the K-12 STEM learning environment successful.

Discussion and Implication

This literature review provides a historical, political and conceptual development of STEM to iSTEM and STEAM over time, as well as the pedagogy and limitations of these frameworks to understand what holds STEM back (used as an umbrella term for STEM, iSTEM, and STEAM) from successful implementation in the classrooms. Researchers and educators disagree on a clear definition and conceptualization of integrated curriculum. Also, the absence of a strong theoretical framework and real-world understanding of the STEM curriculum restricts its implementation (Wang, 2012). The advocates of STEM education insist that STEM gives time and attention to the subjects that are the backbone of any nation's economy; however, iSTEM claims to solve the global challenges of the 21st century regarding energy, health, and the environment (Kelley & Knowles, 2016). Likewise, the followers of STEAM assert positively that it revolves around creative problem-solving techniques that motivate students to create connections between knowledge and skills that help them to solve 21st-century problems (Liao, 2016). Moreover, with all the constraints and challenges that threaten to discontinue the STEM movement, there is significant research-based evidence that STEM is a crucial element of K-12 education but this phenomenon lacks awareness at the university level (Chute, 2009; Daugherty, 2013; DeCoito, 2016; Sanders, 2012; Shanahan et al., 2016).

There is a general understanding among scholars that current education system has marginalized STEM (Kelley & Knowles, 2016; Park et al., 2016).). Due to the political background and impact, the students and other community members perceive it negatively. Another negative impression about STEM is that it is meant for high academic achievers or people who have more interest in science and mathematics (Park et al., 2016). Therefore, it is necessary to promote STEM positively to educate the community and also to motivate students towards STEM-related fields without any political agenda. The main aim of STEM should be to enhance its proficiency among all students, whether they chose to follow the STEM path in postsecondary studies or not. STEM connects to scientific inquiry through the formulation of questions, investigation, engagement, and problem-solving processes. Through engaging students in high-quality STEM activities needs a specific STEM program that includes an accurate curriculum, clear guidelines for the integration of STEM subjects, assessment, and pedagogical approaches.

The STEM program is cumbersome to be implemented because of an inadequate number of experienced teachers, poor quality material, expensive equipment that definitely need much time in preparing and implementing STEM lesson plans and activities. As a result, STEM teachers feel overloaded and overwhelmed (Kanadlı, 2019). However, it can be achieved through the use of a high-quality curriculum and in partnership with certified/licensed arts and non-arts teachers who are involved in teaching artists, art museums, university arts and science education programs and community-based arts organizations (Ria, 2014). The teachers require a quality curriculum (Asghar et al., 2012) with a clear conceptual, theoretical framework and guidelines for the successful implementation of STEM programs. They believe that a flexible curriculum would be valid for various abilities and educational settings and would increase their self-efficacy to teach it (Lehman et al., 2014). STEM curriculum must be explicitly connected with ministry standards and developmentally appropriate (Asghar et al., 2012) to stimulate students' critical thinking and problem-solving skills. Moreover, the teacher should be given a professional development on STEM-based project preparation training that discusses group work, how to create and use easily accessible, and recyclable resources. Meanwhile, extra administrative support, financial support, and reconstruction of the national/provincial curriculum would also benefit teachers. Also, the teacher should be provided with creative tools so they can create, teach, and implement creative lessons, instructional strategies, and assessment practices.

Typical school structures create STEM implementation barriers for teachers in their everyday activities. These structural difficulties include but are not limited to crowded classes, the restricted class schedule for teachers and students, control over the pacing of curriculum and instructions, administrative support, financial support, lack of technological resources (Kanadlı, S., 2019). Many classroom resources, technical resources, time, and effort are required to create these activities, which ultimately increase the teacher's workload. To solve this problem, teachers need administrative and financial support at the district and board levels (Asghar et al., 2012; Park et al., 2017). Likewise, STEM activities are designed for small groups that are difficult to implement in a crowded class or classrooms (Kanadlı, 2019). Furthermore, the inflexible school schedules and restricted nature of some subjects inhibit various teachers from implementing the inclusive nature of STEM lessons. The scheduling limitations also prevented teachers from planning together to create inclusive STEM activities (Dare et al., 2014; Lesseig et al., 2016). Furthermore, to create more STEM literate, the STEM subject teachers need support to explore ways in which they can best foster mutually reciprocal arrangements with other STEM teachers to create an independent, cooperative and symbiotic curriculum. (Bell, D. (2016).

The literature reveals that teachers have a positive perspective about STEM subjects and believe that it motivates students to learn these subjects (Park et al., 2016). This result is quite encouraging because teachers play an integral role in the implementation of either STEM or STEAM or iSTEM. Yet, it is still unknown how to implement this curriculum objective within a current school system. Currently, the elementary teacher's education program prepares teachers to teach all subjects. They feel more confident in teaching STEM than secondary teachers who are trained in specialized subjects only. Therefore, the teacher's education program has to provide training to both elementary and secondary to teach STEM subjects.

The implementation of the STEM program depends upon the well-organized professional development to improve teacher's confidence, knowledge, and efficacy to teach STEM (Lesseig et al., 2016; Nadelson et al., 2012). Active professional development needs to provide opportunities to explore the ways to plan, design, develop and implement while focusing on increasing their content knowledge and skills under STEM expert supervision. Moreover, there is a need for ongoing support for planning and implementation, including support for pedagogical tools, instructional strategies, classroom management, lesson planning around the STEM paradigm (Lesseig et al., 2016).

Globally, almost every nation is rushing to implement the STEM and STEAM initiative that is perceived as an economic, political, and educational savior while many questions arise about ambiguous STEM paradigms. For instance, what is the purpose of education? Why are we teaching STEM to our students? Are we educating our young generation intending to enhance their wisdom, knowledge so that they become active democratic citizens and good human beings? Do we perceive education as a means to create a workforce that is prepared to innovate and compete globally? Does STEM recognize "Science for All" and "Education for All" or continue to portray science as an elitist phenomenon (DeCoito et al., 2016)? Are we filling our children's schedules with STEM or STEAM classes or increasing assessments and challenges? Do these STEM and STEAM's driving forces motivate or demotivate our children to pursue STEM or STEM-related fields?

To conclude, with the evolution of time and circumstances, things change. Likewise, the pedagogical practices vary according to the need of the students, society, time, and economic needs and viability. It is time when researchers and professionals further research and also sit together to discuss and come to a consensus to lift the STEM fog. Moreover, being highlighted globally due to its exponential benefits, STEM, iSTEM, and STEAM are unable to offer some critical solutions to the global economic and educational problems. Then one might ask; What are we looking for? Do we need a one-size-fit-all model? Are we putting the emphasis on input or output? Are we looking for a new model or approach to support our next generation? Therefore, from STEM to iSTEM to STEAM, what is next?

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