AN INVESTIGATION OF STEM EDUCATION RESEARCHERS' AND MIDDLE SCHOOL TEACHERS' CONCEPTIONS OF STEM EDUCATION BASED ON THEIR SELF EFFICACY BELIEFS OF STEM EDUCATION

by

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ABSTRACT

AN INVESTIGATION OF STEM EDUCATION RESEARCHERS' AND MIDDLE SCHOOL TEACHERS' CONCEPTIONS OF STEM EDUCATION BASED ON THEIR SELF EFFICACY BELIEFS OF STEM EDUCATION

This study was designed to investigate STEM education researchers' and middle school teachers' conceptions of STEM education based on their self-efficacy beliefs of STEM education. This study is designed as explanatory case design qualitative method study. The participants of this study were 9 STEM education researchers and 9 middle school teachers who were selected based on their self-efficacy beliefs which measured by Teacher Self-Efficacy Scale for STEM Practices (TSESSP). In order to investigate the conception, qualitative data obtained through semi structure interviews were obtained using The STEM Education Conceptualization Level Determination Interview Protocol (SECLDIP). The interviews of the participants were transcribed verbatim and open coded. Based on the results of the analysis, it was concluded that since middle school teachers implement STEM education in their courses, there are certain commonalities in the conceptualization of STEM education between STEM education researchers and middle school teachers. However, STEM education researchers convey theoretical understanding with examples that illustrate the integrated character of STEM education while middle school teachers have a grasp that STEM education is an interdisciplinary activity, and their understanding is limited to classroom practices rather than theoretical components. In addition, it was concluded that for the aspects of *nature and scope of integration* and *implementation*, the answers get more problem based with disciplinary integration as the self-efficacy belief increases.

ÖZET

STEM EĞİTİMİ ARAŞTIRMACILARININ VE ORTAOKUL ÖĞRETMENLERİNİN STEM EĞİTİMİNE İLİŞKİN KAVRAMSALLAŞTIRMA DÜZEYLERİNİN STEM EĞİTİMİ ÖZ YETERLİLİK İNANÇLARINA DAYALI İNCELENMESİ

Bu çalışma, STEM eğitimi araştırmacılarının ve ortaokul öğretmenlerinin STEM eğitimine ilişkin öz-yeterlik inançlarına dayalı olarak STEM eğitimi anlayışlarını araştırmak için tasarlanmıştır. Nitel araştırma yöntemlerinden açıklayıcı durum deseninin kullanıldığı bu çalışmanın katılımcıları, STEM Uygulamaları için Öğretmen Öz-yeterlik Ölçeği (SUÖÖÖ) ile ölçülen öz-yeterlik inançlarına göre seçilen 9 STEM eğitimi araştırmacısı ve 9 ortaokul öğretmenidir. Kavramsallaştırma düzeylerini değerlendirmek için, yarı yapılandırılmış görüşmeler yapılarak elde edilen nitel veriler STEM Eğitimi Kavramsallaştırma Düzey Belirleme Görüşme Protokolü (SEKDBGP) kullanılarak elde edilmiştir. Katılımcılarla yapılan görüşmeler birebir yazıya dökülmüş ve açık kodlanmıştır. Analiz sonuçlarına dayalı olarak, ortaokul öğretmenlerinin derslerinde STEM eğitimini uygulamış olmaları nedeniyle, STEM eğitimi araştırmacıları ile aralarında STEM eğitiminin kavramsallaştırılmasında bazı ortak noktaların olduğu sonucuna varılmıştır. Ancak, analiz sonuçları, STEM eğitimi araştırmacılarının, STEM eğitiminin bütünleşik yapısını gösteren örneklerle teorik anlayışı aktardıklarını, ortaokul öğretmenlerinin ise STEM eğitiminin disiplinler arası bir etkinlik olduğunu kavradıklarını ve anlayışlarının teorik olmaktan ziyade sınıf uygulamaları ile şekillendiğini ortaya koymuştur. Ayrıca, öz-yeterlik inancı attıkça, entegrasyonun doğası ve kapsamı ve uygulama temaları açısından, cevapların farklılık gösterdiği ve disiplin entegrasyonuna dayalı olarak cevapların daha fazla sorun çözmeye dayalı olduğu sonucuna varılmıştır.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS

M	Mean
MD	Mean Difference
N	Number of Participantse
SD	Standard Deviation

LIST OF ACRONYMS/ABBREVIATIONS

MST	Middle School Teachers
MSST	Middle School Science Teachers
MSMT	Middle School Mathematics Teachers
MSITT	Middle School Information Technologies Teachers
SECLDIP	STEM Education Conceptualization Level Determination Interview Protocol
STEM	Science, Technology, Engineering, Mathematics
STEMER	STEM Education Researchers
RQ	Research Question
TSESSP	Teacher Self-Efficacy Scale for STEM Practices

1. INTRODUCTION

Science, Technology, Engineering and Mathematics (STEM) education is an educational approach that creates an area for students to develop critical thinking skills in order to solve real life problems creatively including ideas or solutions representing something in high quality. STEM education has received substantial attention as a reform for economic growth and national security. The skills that the students gain over K-12 education with the STEM integrated structured curriculum provide national workforce to the economy of a country, that creates advantage in STEM fields such as engineering and technology in the pursuit of innovation (Butz, *et al.*, 2004). In addition, STEM education also provides a certain level of scientific literacy which is important for the informed decision-making process. It is enhanced by the knowledge that can be gained through STEM education in science, technology, engineering and mathematics disciplines. Hence one of the goals of STEM education is to let students gain an understanding of the STEM concepts including scientific and mathematical concepts and processes in order to raise a generation that can participate making logical decisions process individually about civil and cultural affairs (National Research Council, 2011).

Even if it is underlined and put strong emphasis on STEM education, it has not been widespread enough to teach about cultivation of the technique depending on variety of reasons. Therefore, the development of students with adequate competence has fallen short (Rosenblatt, 2005). It needs to be taken into consideration that school curriculum structure is resilient for sudden changes and the lack of readiness of educators to implement the integrated STEM education approach might be hard to transfer into their teaching (Schleigh, Bossé, and Lee, 2011). Accepting and implementing a reform in educational setting is a highly personal developmental process that takes time and effort. Therefore, curriculum integration might assist educators to adopt STEM education principles yet, the implementation process for educators would take a while to be settled in schools and student comprehension and indication the expected outcomes might be a long term in the economy and workforce (Corlu, Capraro and Capraro, 2014).

In this context, teachers' knowledge and beliefs about the curriculum, which are some of the important factors affecting the success of a curriculum in the implementation process, determine how and to what extent the curriculum serve to the objectives and the purpose (Aydın and Boz, 2012). STEM educators are hesitant to use STEM education in their classrooms because they are uncomfortable with it (Nadelson *et al.* 2013). It was discovered that STEM educators have just the most fundamental understandings of STEM education. This might be detrimental to students' understanding of STEM concepts as well as educators' adoption of STEM teaching methods into their practice (Magnusson *et al.* 1999). One of the most important prerequisites for implementing STEM education in accordance with its purpose to provide students with a high level of proficiency education is professional development. STEM education researchers are the ones who can establish a profound curriculum and educate in-service teachers with a professional development programs for better practice of teaching. Professional development programs offer unique chances for advancing professional knowledge (instructional product) and academic knowledge, as well as for bridging the gap between theory and practice (Huang and Shimizu, 2016).

Among the various aspects that might affect the implementation of STEM education, the focus of this study is to explore the STEM education conceptions of STEM education researchers and middle school teachers who have different level of self-efficacy beliefs of STEM education. The study includes STEM education researchers as participants because of their comprehensive knowledge gained through publication phases including reviewing the related literature and conducting their own research about STEM education. Investigating both STEM education researchers and middle school teachers would provide extensive information if there is theory-practice gap in terms of STEM education conceptions which is one of the components in teaching for effective practice.

2. REVIEW OF LITERATURE

2.1. Need for STEM Education

Over the last decade in PK-12 education, STEM education has become one of the largest reform movement in the world. Politicians, federal and state agencies, for-profit and non-profit groups, corporations, and the media are promoting, funding and discussing the importance of STEM education and initiatives (Daugherty, 2013). Since the 1990s, the idea of STEM education contemplated by the National Science Foundation (NSF) which used the abbreviation "*SMET*" as shorthand for "*science, mathematics, engineering, and technology*". At those days, STEM funding for research and education had gained importance in the United States due to the reason that authorities realized the country may regress in the global economy. Educational stakeholders began to mainly focus on STEM education and careers (Sanders, 2009).

The number of workers in the STEM field workforce increase in the demand. Apart from the workforce and productivity of a nation that serves for a benefit of a country, STEM education is also crucial for the personal level of awareness to drive a meaning out of the world such as natural cycles that leads to life, cause and effect of climate crises or working principle of a technological device. At both level personal and professional levels, it is important to gain competencies in logical thinking and critical reasoning which studies show STEM education is linked to an increase for both skills (Sadler and Zeidler, 2005).

One of the ways to overcome the challenges of the 21st century is STEM education. The criteria for the national workforce in the 21st century underline the significance of having good problem solving and critical thinking skills, being creative and innovative and being able to work in teams which STEM education provides (Wan Husin, *et al.*, 2016). The challenges were also supported by the reports containing warning of an imminent shortfall of skilled workers. It is mentioned that, based on surveys, 70 percent of employers are listed as lack of employability skills. Unless the education system is changed significantly, workers with necessary skills would not be raised (National Association of Manufacturers, 2001). It shows that why STEM education has gained importance for its integration into the curriculums of countries to meet the requirement of the 21st century.

According to Thomasian (2011), STEM education has two main purposes. The first is to increase the number of students who will choose a profession related to science, technology, engineering and mathematics disciplines at the university level, and the second is to increase the basic knowledge level of students in science, technology, engineering and mathematics disciplines and to enable them to apply creative solutions in their daily lives to solve the problems related to these disciplines.

Outstanding benefits of STEM education to students are developing their problem-solving skills, making them innovators, encouraging them to being inventors, increasing their self-reliant, supporting logical thinking and raise them as technologically literate individuals (Morrison, 2006). In addition, Yıldırım and Altun (2015) stated that STEM education supports students' in terms of;

- creativity,
- designing ability to develop prototypes in the field of engineering by using their basic knowledge and skills,
- ability to think logically and critically,
- interdisciplinary perspective and relate the learned information from discreate disciplines,
- confidence,
- learning process with fun and enjoyable STEM activities,
- permanent learning as well as their ability to associate newly learned concepts with previous learned information.
- ability to understand and explain the nature of technology.

STEM education should be integrated and planned with a perspective that improves students' capacity to use technology, increases their engineering and design skills, and makes them realize how the real world works and devices are used in daily life (Bybee, 2010). According to the finding of the research of Frykholm and Glasson (2005), implementing an interdisciplinary or integrated curriculum allows learners to have more meaningful, less fragmented, and exciting experiences. The "*separate subject*" or "*layer cake*" approach to knowledge and skills that are gained over separate classes is being more recognized by educators as one of the core challenges in today's classrooms because students frequently struggle to solve problems caused by lack of awareness in the context in which problems are embedded (Frykholm and Glasson, 2005).

With taking into consideration the aspect which STEM education provides to learning process and to the future of students, STEM programs are required in schools' curricula. Glasgow (1997) stated that requirements of life crucially include continued learning and enhanced problem-solving skills. The teaching process in classroom settings involving variety of learning activities should reflect the outside world conditions by providing a connection the process in the classrooms to the real world. It needs to be confirmed that interdisciplinary activities which STEM education provides, should be integrated in the school curriculum and programs. Achieving the purpose of educational activities offered in schools and outside of school is only possible by properly planned education and accompanying educational programs. An integrated STEM curriculum would be a guidance for many teachers for seeking better practice and having significant results in the long term with valid planning and instructions.

In the recent years, political, civic and industry leaders along with the educators concluded that science, technology, engineering and mathematics (STEM) disciplines should be integrated in school system (Technology Student Association, 2011, as cited in Asunda, 2014). Curriculum integration enables educators to see four STEM fields as a single entity with a strong link to real life. Several historical events lead to STEM education to be emerged and integrated into national curriculums. Morrill Act of 1862 was one of the significant ones that can be accountable for the development of land grant universities in the United States of America. These universities mostly focused on agricultural training yet led to the establishment of engineering-based training programs (Butz *et al.*, 2004). Other significant events that contributed STEM education to be grown were the World War II (WWII) and the launch of the first satellite Sputnik by Russia (White, 2014). During WWII, STEM education was the significant tool that caused military and scientists to develop technology which eventually might help winning the war. Even though, STEM education was used, and innovations were launched, it was not applied to educational settings (Rifandi and Rahmi, 2019).

Developed and developing countries make some changes in their educational systems in parallel with the changes and developments in the world's economic, social and political fields. These changes have a great influence in the educational programs in Turkey as well as in other countries such as European Union (EU) countries, Asian countries or US. The implementation of STEM education in Turkey is based on a very recent history. The education system of the Republic of Turkey entered a renewal process with a gradual curriculum that started in 2004 and innovations were made in all education programs from primary education to university (Boynukara, Deniz and Tüysüz, 2020). The subject of technology was added to the science curriculum in 2005, and the course was renamed as Science and Technology, with the weekly course length expanded from three to four hours (MEB, 2005). Along with the changing science education program, it was aimed that individuals should be willing to learn the subjects, entrepreneurial, able to observe, adapt quickly to newly developed technologies and use these technologies, discover, collect data, and produce solutions to problems.

In this respect, it was thought that the STEM approach, based on an educational approach that integrates different disciplines, was suitable for teaching science courses. In this context, with the regulation made in Turkey in 2017, STEM was included in the natural Science Curriculum as "*Applied Science Learning*". Within the scope of this learning area, a "*Science and Engineering Practices*" unit was added to the science textbook (MEB, 2018). The progress of Turkish science curriculum through many years gave its last product as a new science curriculum for the academic year of 2018 - 2019 for the all-grade levels in middle schools. The latest changes focus more on the science and technology, integration of different disciplines, and hands-on practices of integrated disciplines rather than memorizing the textbook information only in one discipline. According to newly explored developments and the dominant trends in education, the aims and components of the programs have been structured by changes in curricula in middle school (Çiray, Küçükyılmaz and Güven, 2015). Even though, newly trends influence the curriculum development and there are various studies on STEM education in the international literature, the application of STEM education has not become widespread yet in Turkey's classroom settings (Gülhan and Şahin, 2016).

2.2. Barriers to Implementation of STEM Education

In spite of the deficient consensus related to the details of STEM education, STEM agenda is pushed to be applied and integrated by national and policymakers. Common STEM standards and curriculum frameworks should be put in place before integration of STEM disciplines due to the reason that they provide clear signals to identify what to occur and what outcomes to gain at the end of the integration (Asunda, 2014).

Even if the STEM education has become one of the focus points in the educational system and has been integrated into curricula, it has mostly failed to apply it in the learning process of students. The school settings around the globe putting more emphasis in the implementation of STEM education that prepares future workforce of individuals to be competent with strong knowledge to enhance the development of pupils' skills across STEM disciplines. However, the implementation of STEM education for pupil to gain various competencies mostly fail in the classrooms (Ejiwale, 2013). Ejiwale (2013, pp.64-69) listed ten different reasons why the STEM education application may fail in the educational setting. The list includes:

(i) Poor preparation and shortage in supply of qualified STEM teachers,
(ii) Lack of investment in teacher's professional development,
(iii) Poor preparation and inspiration of students,
(iv) Lack of connection with individual learners in a wide variety of ways,
(v) Lack of support from the school system,
(vi) Lack of research collaboration across STEM fields,
(vii) Poor Content preparation,
(viii) Poor Content delivery and method of assessment,
(ix) Poor Condition of laboratory facilities and instructional media,
(x) Lack of hands-on training for students.

The State Educational Technology Directors Association (SETDA) (2008) published a report called Science, Technology, Engineering and Math containing a section about the barriers to STEM education. The report states that the barriers have three aspects including students, educators and schools. In the school perspective, variety of reasons related;

- curriculum and credit issues,
- lack of funding,
- lack of qualified teachers and,
- inadequate policies to recruit and retain STEM educated teachers, were listed as

hinders STEM education to be fully integrated. From the educator's aspect, the problems lie under;

- retaining teachers with a STEM background,
- STEM-trained professionals not pursuing teaching,
- difficulty in advancing professionally,
- lacking adequate preparation for teachers by higher education and
- classroom time constraints.

When we examine the intersection of the barriers containing teacher and school or maybe government perspectives, "*finding qualified teachers*" from the school perspective and "*getting adequate preparation for teachers by higher education*" from the teachers' aspects overlap because one cause another (Hossain, 2012).

Ejiwale (2012) supports the point of view that interdisciplinary STEM education in school curriculum is important while taking attention to the roles of educators. The success that pupils gain over the STEM activities is related to the level of readiness that STEM educators have. While encountering difficulties in the application of STEM, the STEM educators need to introduce practical and relevant experiences and ensure motivation and active participation of students. Lesseig *et al.* (2016) implies that one of the major challenges in the successful implementation of STEM education is teachers. Teachers are unsure how to teach STEM using integrated techniques such as problem or project-based learning, as well as how to construct STEM activities while maintaining disciplinary integrity because most teachers have obtained diploma or license only in one subject (Honey *et al.* 2014; Shernoff *et al.* 2017).

Through semi-structured interviews with K-12 STEM education teachers, Shernoff, Sinha, Bressler, and Ginsburg (2017) outlined the problems that teachers encounter in implementing STEM education as coming up with the following six crucial points:

- Lack of knowledge of the multidisciplinary character of STEM-based curriculum, particularly how to integrate STEM-related disciplines effectively.
- A lack of comprehension of content and standards in disciplines other than their own field, particularly what engineering education entails.
- A lack of time for collaborative planning, knowledge sharing from other disciplines, establishing STEM curricular activities with other instructors, and conducting STEM teaching and learning activities.
- The impact of school structure and organization; the impact of standard tests.
- There aren't enough instructional resources and materials.

In this context, one of the most important prerequisites for the integration of STEM education in accordance with its purpose and for providing students with a high level of education is teacher education. For STEM education to be implemented in accordance with the purpose of integration in educational environments, teachers must have certain experience and skill in this regard (Corlu, Capraro and Capraro, 2014). According to the National Center on Education and the Economy (NCEE,2006), one of the fundamental problems with lack of qualified teachers is training system that raise future teachers who will be the one to apply STEM education in the classroom. The training of teachers in the universities or in the professional life are so important when the curriculum developments take place to implement the curriculum at high level of proficiency. Professional development is considered as a crucial tool for educational reform to improve classroom instructional practices in schools (Gibbons, Kimmel and O'Shea, 1997).

Teacher training institutions, which have a history of 150 years and continued their activities under the Turkish Ministry of National Education, have been transferred to universities since 1982 (Akyüz, 2001). As in every change, the quality of the teachers trained in this transition period in which teacher training was transferred to universities has been the subject of discussion. Universities along with the Council of Higher Education (CoHE) and the Ministry of Education (MoNE) are engaged in Turkey's education system for the training of STEM teachers (Corlu, Capraro and Capraro, 2014). In the study of Çorlu, Capraro and Capraro (2014) in which they analyzed the effects of the STEM model on teacher training, they found that, considering the professional development and reforms in Turkey, as a result of the specialization of teachers in their own fields, they do not have adequate competencies to educate the future workforce. The universities in Turkey struggle to meet European Union criteria for instructional quality, research, and academic freedom (Türkiye Bilimler Akademisi, 2010). In addition, the profit quick-fix teacher certification programs offered by the universities are inadequate to train in-service teachers to improve their STEM education competencies (Corlu, Capraro and Capraro, 2014).

The development of teacher beliefs, self-efficacy, content knowledge, pedagogical content knowledge, technology abilities, and curriculum design has been the focus of the literature on teacher PD programs for STEM education (Ring *et al.*, 2017). These programs are designed to equip instructors to teach STEM in an integrated manner by improving their subject knowledge in STEM disciplines, introducing novel teaching methods for interdisciplinary learning, and scaffolding learning outcomes. Regarding to STEM education, teachers are not only experts, but also have an extra obligation of mentoring their students in at least one other STEM subject, which requires an investment in in-service teacher's professional development as well as reforming teacher education programs at universities (Kline, 2005; Sanders, 2009).

2.3. Research and Practice Gap in Education

Given that one of the ultimate purposes of educational research is to generate information that enhances educational practice, one would expect practitioners (teachers, policymakers, and educational materials producers, among others) to apply the knowledge gained via educational research. However, both academics and practitioners agree that there is a disconnect between research and practice in education (Broekkamp and van Hout-Wolters, 2007).

The research-practice relationship is a topic that is regularly and continuously discussed (Runesson Kempe, 2019). Hillage *et al.* (1998, p. 46) stated in their study that if the goal of educational research is to inform educational decisions and actions, then it can be concluded that research is insufficiently informing practitioners' actions and decisions. McIntyre (2005) claimed that there is a significant gap between the knowledge that educational research has generated and the practice of teaching. The gap mainly caused by the impersonal character of research-based knowledge and the extremely personal nature of teaching which are two related contrasts causing two types of knowledge. While research-based knowledge about best practices is expressed in broad terms through published research, classroom instruction and practice are inherently and profoundly personal. Teachers' instruction relies heavily on their personal knowledge which the usability and practicality is primary concern.

Hasanah and Tsutaoka (2019) identified thirteen constraints as intrinsic barriers in their study of literature review which was emerged more than the extrinsic and institutional barriers to the implementation of STEM education. The majority of them concentrated on educator education, and educators' capacity to comprehend STEM education as well as pedagogical knowledge. Although, there are no research found in the literature that emphasizes the research-practice gap in STEM education, it can be concluded that STEM education teachers fail to fully understand what STEM education contents and appropriate pedagogy to implement STEM education which can be interpreted as an indicator to research-practice gap in STEM education.

Teachers must continue to learn necessary STEM content knowledge and pedagogical content knowledge in order to provide effective STEM instruction, which includes incorporating research-based knowledge into their work. However, many instructors regard educational research and theories as irrelevant to their daily lives, resulting in a gap between theory and practice that continues to obstruct educational advancement (Nuthall, 2004). Teachers who valued both research and practice in their pre-service educations were shown to favor practice after they started teaching (Allen, 2009). Kieran and colleagues (2013) emphasized the necessity of recognizing teachers as major stakeholders in research in order to connect research and practice, resulting in both professional and academic knowledge. Although strategies such as action research and the use of case studies have been proposed to help teachers bridge the gap between theory and practice (van Driel, Beijaard, and Verloop, 2001), there is still a need to better understand teachers' thinking and find new ways to enable them to connect research and practice in meaningful ways.

Korthagen (2007) described the gap between teachers and researchers as theory-practice gap underlying that there is a critical need for researchers and practitioners to form collaborative communities that are composed of both a research and a practical emphasis. It is crucial for STEM education researchers and middle school teachers to establish collaborative communities because participating in integrated STEM professional development improves teachers' perceptions, conceptions and self-efficacy beliefs of STEM education significantly, resulting in increased teacher aptitude to teach STEM subject (Nadelson, Seifert, Moll and Coats, 2012).

2.4. Defining and Conceptualizing STEM Education

STEM education became a crucial element in education with the recognition of legislators and educational administrators. STEM education is called a meta-discipline that underlies its nature since it has a created interdisciplinary approach including the integration of different disciplinary knowledge (White, 2014). It serves as a bridge between the variety of discrete disciplines such as Science, Technology, Engineering and Mathematics to unite certain knowledge and combine them in a new entity ensuring the constitution of multidisciplinary perspective (Morrison, 2006).

Over the last decade in PK-12 education, STEM education has become one of the largest reform movement. Politicians, government agencies, for-profit and non-profit groups, corporations, and the media are promoting, funding and discussing the importance of STEM education and initiatives (Daugherty, 2013). However, STEM education does not have a deep-rooted history. The short-term standing past reaches back to 90s that the students were directed to learn across the STEM fields when US National Science Foundation (NSF) officially gravitated towards technology and engineering literacy into the formal education system that already put great emphasis on science and mathematics in undergraduate and K-12 school education (National Science Foundation, 1998; Li, Wang, Xiao and Froyd, 2020).

According to Sanders (2009), SMET is the first acronym used for science, technology, engineering and mathematics by the National Science Foundation (NSF) in 1990s. The term STEM was first used by American Biologist Dr. Rahmaley (former director of the National Science Foundation) and it was introduced at the U.S. National Science Foundation (NSF) in 2001 (White, 2014; Özdemir, Yaman and Vural, 2018). The reason behind such change was lying under the reason that "SMET" was similar to the sound smut (dirty mark, sooty matter) causing issue of vulgarity so that the words were arranged to create STEM that became the acronym of choice (Sanders, 2009).

The abbreviation STEM stands for science, technology, engineering, and mathematics, but it has evolved to symbolize a multidimensional concept that connects education, employment, and production (National Science Foundation, 2010). In contrast to how simple what STEM stands for, it is much harder to define it in the educational context because of its complex character. Even, the trend of STEM is getting popular and recent research increases in number, the acronym STEM has not been conceptualized into one common point and has not been created a clear definition due to its variety of aspects and lack of common perception of what it represents (Herschbach, 2011; Assefa and Rorissa, 2013).

Despite the fact that STEM education does not have an agreed definition conceptualized by the educational stakeholders (English, 2016; Srikoom, Faikhamta and Hanuscin, 2018), it is clear that STEM education is crucial and each individual in the society needs to gain certain amount of STEM literature (Marder, 2013). The definitions of STEM education contain commonality even though those vary in exact statement. The descriptions in the definitions have in common that STEM is an interdisciplinary approach to learning meaning that academic concepts in the curriculum are integrated and combined with real life applications through lessons in science, technology, engineering, and mathematics disciplinary contexts to establish meaningful connections between school and real-world (Tsupros, Kohler and Hallinen, 2009).

From the perspectives of policy makers such as legislative organizations and educational stakeholders, STEM education often mistaken as a traditional approach lacking interdisciplinary integrated manner (Breiner *et al.*, 2012). Labov, Reid and Yamamoto (2010) underlined the most crucial characteristic of STEM education that needs to be included while conceptualizing is the notion of integration. The concept of STEM education contains the perspective that is a meaningful and purposeful integration of STEM disciplines and disciplinary concepts in order to solve real life problems. Bybee (2010) also argues that STEM is a word that is frequently used to refer to science or mathematics, but it should also refer to a greater emphasis on technology and engineering in school programs. Bybee (2013) also stated that the meaning of STEM on this subject is not clear yet, and while studies refer to four disciplines, namely science, technology, engineering and mathematics, sometimes only one discipline is emphasized, sometimes four disciplines are assumed to be separate but equal, and in some definitions emphasized the integration of these four disciplines.

Vasquez, Sneider and Comer (2013), revealed the complexity of STEM education by examining the statements that demonstrate researchers' views of integrating various disciplines and put into terms by researchers as multidisciplinary, interdisciplinary, and transdisciplinary approach. Individuals who refer to STEM education as any of the four disciplines (science, technology, engineering and mathematics) and the individuals addressing areas in which all four subjects (science, technology, engineering and mathematics) overlap, creates an ambiguity when it comes to the nature of STEM. What clear is, STEM is not defined precisely and distinctly by the groups that make use the concept.

STEM education may be regarded from a wide and inclusive viewpoint to involve education in individual STEM fields, such as science, technology, engineering, and mathematics, as well as interdisciplinary or cross-disciplinary combinations of individual STEM disciplines (Li, Wang, Xiao and Froyd, 2020). The majority of definitions focused on integrating one or more STEM fields into the teaching and learning process. Sanders (2009), for example, described integrated STEM education as "*approaches that investigate teaching and learning across/among any two or more STEM subject areas, and/or between a STEM topic and one or more other school subjects*".

Merrill and Daugherty (2009) suggested that STEM education is a meta-discipline conducted by teachers and educators at a school level especially in science, technology, engineering and mathematics fields with the integrated approach which the experience is composed of one united dynamic study including the combination of the STEM disciplines instead of dividing the contents of the specific discipline. STEM needs to be "fluid" meaning that all the necessary knowledge built by discrete disciplines would be connected smoothly in a learning activity with a purpose. In their report, Akgündüz, Ertepınar, Ger, Kaplan Sayı and Türk (2015) defined STEM education as a teaching approach in which the concepts of science, technology, engineering and mathematics disciplines are presented together in an integrated manner for the same goal with common achievements. Instead of using the four disciplines separately, STEM ensures disciplinary concepts to be integrated with each other by interdisciplinary collaboration among and between the subjects referring the connection between subjects.

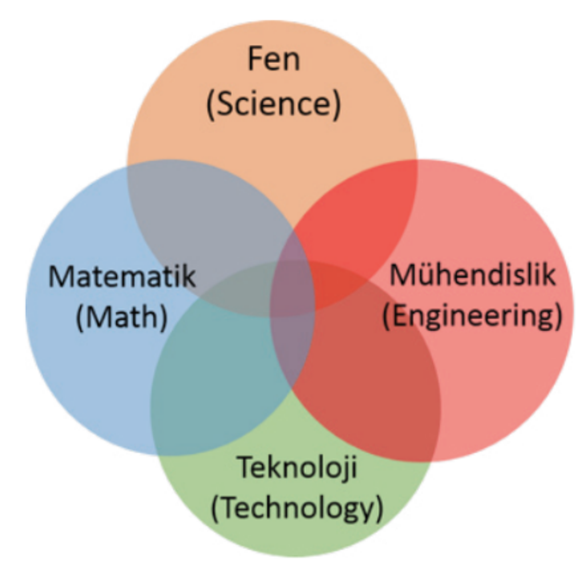


Figure 2.1. Integrated STEM Education (Akgündüz *et al.*, 2015).

STEM education, as defined by Bybee (2010), is a method of teaching scientific and mathematical subjects through the integration of technology and engineering from pre-school through the 12th grade. In the description that have been done by Honey, Pearson and Schweingruber (2014), STEM education is pictured as a bridge connecting multiple disciplines in the context of complex situations and phenomena via on tasks activities which requires application of different disciplinary knowledge. It is also indicated that STEM refers to an integrated teaching and learning approach which different disciplinary content and practices are used for a purpose to solve a real-life problem.

As mentioned above, it can be concluded that STEM education has been characterized from many perspectives. Based on the purpose of the implications, the definitions could be used. A wide range of definitions are feasible depending on contextual circumstances such as the functions of stakeholders in the implementation of a STEM program. However, it is also important to make frequently used concepts clear for the basis of the STEM education integration to gain deeper understanding.

2.4.1. Integrated STEM Education Models

In the literature, three approaches emerge to define the path followed in the integration of curriculum and the degree of integration: multidisciplinary, interdisciplinary and transdisciplinary (Drake and Burns, 2004). When the level of integration of disciplines is defined at an increasing level from discrete to multidisciplinary, interdisciplinary and transdisciplinary, it continues with a continuum that includes more connections and interactions between disciplines. Regarding to the integration of multiple disciplines, these concepts are frequently encountered in the definitions of STEM education.

Some studies employ teaching techniques to categorize distinct forms of curricular integration, in addition to Drake and Burns' (2004) methodologies. Fogarty (1991) used ten models to classify a continuum of integration: fragmented, connected, nested, sequenced, shared, webbed, threaded, integrated, immersed, and networked. The 10 models described the progress along a continuum to integrate curriculum from a single discipline to intensely addressing personal interest. Fragmented, connected, and nested models are in the category of "within single disciplines" that respectively meaning a single discipline only, focusing on a skill or concept within a single discipline and focusing on multiple skills or concepts within a single discipline. Sequenced, shared, webbed, threaded, and integrated models are efforts across multiple disciplines that are in the category of "across several disciplines". Sequenced model represents cross-discipline and focuses on the structuring of curriculum to establish linkages in the sequenced approach. Shared model means that two disciplines are combined into one focus point such as subject knowledge or development of skills. A topic or a problem that is utilized to connect cross-discipline components is referred to as a webbed model. Threaded model concentrates on a variety of cross-discipline skills and integrated model emphasizes the development of overlapping content knowledge and abilities for more than two disciplines. The immersed and networked models which are the efforts that focus on personal interests, are in the category of "*inside the mind of the learner*". Different topics identified by learners are utilized to address learners' interests in an immersed model and different fields are employed without limits to address the interests of learners in a networked model. Figure 2.2 demonstrates the visual equivalance of the Fogarty's (1991) ten models.

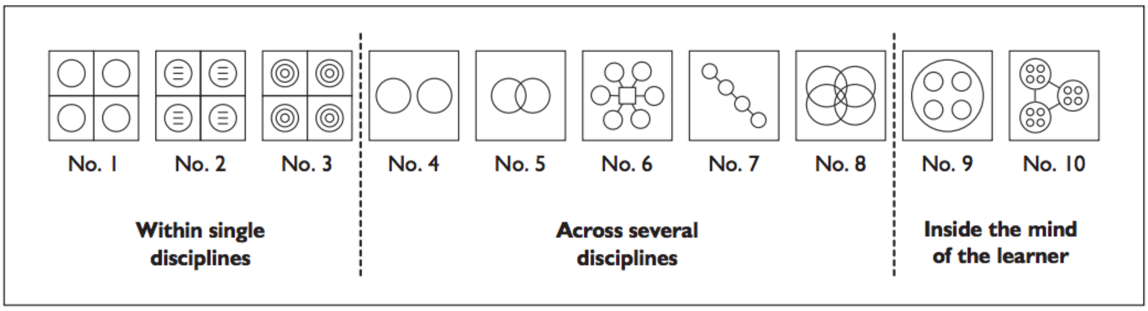


Figure 2.2. How to integrate the curricula (Fogarty, 1991, p.62; Fogarty and Pete, 2009, p.11).

The integrated term is difficult to differentiate from comparable concepts such as connected, unified, multidisciplinary, cross-disciplinary, or transdisciplinary since the boundaries of the integrated concept employed in educational practices and research are fluid. The fact that connections can be expressed at multiple levels at the same time, such as in a student's thinking or behavior, in a teacher's instruction, in the curriculum, between and among teachers, or in larger units of the education system, such as the organization of an entire school, makes defining integrated STEM education even more challenging (Honey, Pearson, and Schweingruber, 2014).

2.4.2. Subcomponents of Integrated STEM Education

A conceptual framework that goes beyond a basic description including the reasoning, goals, expected outcomes, components, and how the components interact is required for support of integrated STEM education to acquire significant momentum. A conceptual framework can also aid the development of a research agenda that will enlighten stakeholders and allow integrated STEM education to reach its full potential (Kelley and Knowles 2016). "*Descriptive Framework*" was developed by Honey, Pearson and Schweingruber (2014) to make sense of confusing nature of STEM education. The framework was designed to give academics, practitioners, and others a shared perspective and vocabulary to identify, analyze, and investigate unique STEM dimensions within the educational context. Although some other elements may be included in such a framework, it was decided to concentrate on four high-level characteristics: goals, outcomes, nature of integration, and implementation. These components were to provide a common framework for researchers and practitioners to identify and describe their STEM practice initiatives. The Figure 2.3 represents the Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education.

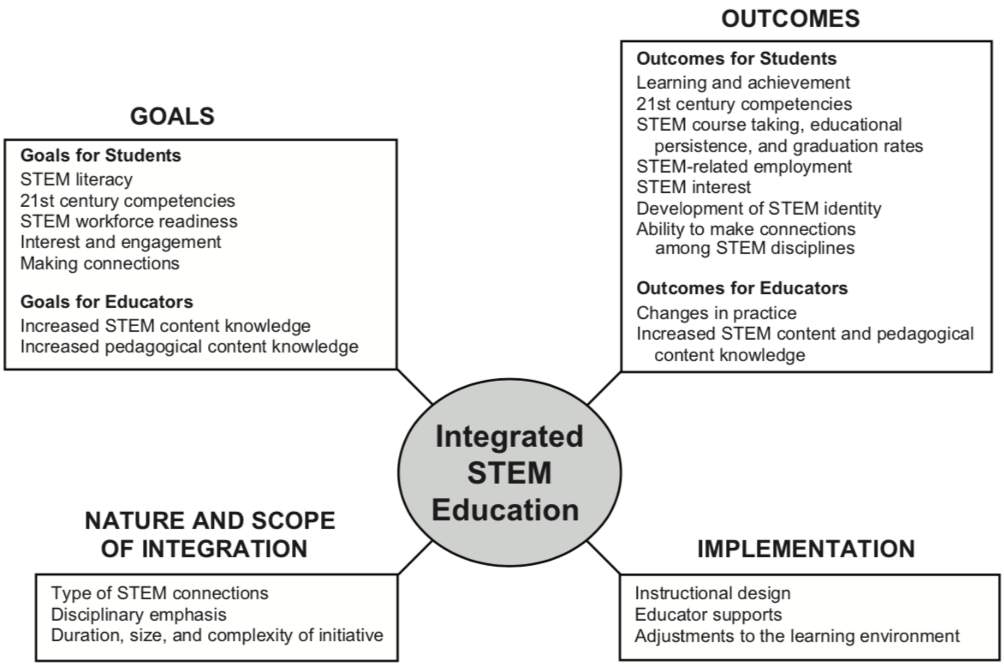


Figure 2.3. Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education (Honey, Pearson and Schweingruber, 2014, p.32).

2.4.2.1. Goals of Integrated STEM Education. Goals are the statements that describe what the designer of a certain educational intervention aims to achieve. They are significant to establish a driving force behind an iterative process of educational transformation. The ‘*‘Descriptive Framework*” includes 5 goals for students and 2 goals for educators. Honey, Pearson and Schweingruber (2014, p.33) states the goals as;

Goals for Students:

- STEM literacy,
- 21st century competencies,
- STEM workforce readiness,
- Interest and engagement,
- Ability to make connections among STEM disciplines.

Goals for Educators:

- Increased STEM content knowledge,
- Increased pedagogical content knowledge.

(i) **STEM Literacy and 21st Century Competencies.** Although much work has gone into clarifying aspects of literacy in the particular STEM disciplines, STEM literacy is a relatively new concept that has not been clearly defined in literature or practice. STEM literacy may be defined as a mix of (i) awareness of the roles of science, technology, engineering, and mathematics in today's society, (ii) familiarity with at least some of the fundamental principles in each discipline, and (iii) a basic degree of application fluency (Honey, Pearson and Schweingruber, 2014).

Twenty-first-century *competencies* are a combination of cognitive, interpersonal, and intrapersonal traits that can help people learn more deeply and transmit their knowledge. *Critical thinking and innovation* are the examples of cognitive competencies; interpersonal attributes such as *communication, collaboration*, and *responsibility* are examples of interpersonal attributes; and intrapersonal traits such as *flexibility*, *initiative*, and *metacognition* are examples of intrapersonal traits (Honey, Pearson and Schweingruber, 2014).

(ii) **STEM Workforce Readiness.** The creation of a STEM-capable workforce is one of the goals of integrated STEM education. The aim is to increase the number of people who (i) develop STEM skills through different experiences (ii) earn STEM related degrees that prepares pupils for jobs like K–12 STEM teachers, medical assistants, nurses, and computer and engineering technicians, or (iii) pursue professional degrees in one of the STEM areas (Honey, Pearson and Schweingruber, 2014).

(iii) **Interest and Engagement.** Another purpose of integrated STEM education program is to increase interest and participation in STEM disciplines. Some programs encourage all kids to be interested in STEM, while others target certain groups, such as those who have been historically underrepresented in STEM areas (Honey, Pearson and Schweingruber, 2014).

(iv) **Ability to Make Connections Among STEM Disciplines.** Because integrated STEM education necessitates cross-disciplinary links, it is critical to raise students' and instructors' awareness of these connections and to use them to promote learning. Connections may also rely on a synthesis of methodologies from several disciplines to provide a comprehension of fundamental concept or major idea, resulting in knowledge that is more integrated, broader in scope, or distinct than understandings established within the limits of a single field. The competencies of STEM education aim to develop to make connections among STEM disciplines are;

- understanding and using concepts with many meanings or applications in various disciplinary contexts (transfer),
- using information from a separate field, such as mathematics, in a STEM practice, such as engineering design,
- solving an issue or completing a project by integrating approaches from two or more STEM fields (e.g., scientific experimentation and engineering design),
- identifying when a subject or practice is presented in a holistic manner, and
- understanding when to call on discipline knowledge to facilitate integrated learning experiences (Honey, Pearson and Schweingruber, 2014).

(v) **Increased STEM Content Knowledge and Pedagogical Content Knowledge.** Some integrated STEM education initiatives, rather than or in addition to pupils, focus on in-service teachers, usually through professional development activities related to a specific curriculum. The goal of many of these programs is to improve teachers' subject-matter and pedagogical content knowledge, which is applicable to both specific STEM disciplines and developing links between and among them. A complementary objective is to improve instructors' instructional skills in disciplines that they may not have had much experience with.

2.4.2.2. Outcomes of Integrated STEM Education. Despite the limited outcomes for STEM education programs for students, it is critical that the framework incorporate outcomes, if only to emphasize the need of structuring integrated STEM experiences in such a manner that their influence on students can be measured. The framework considers the fact that integrated STEM education will likely have an influence on many instructors in both preservice and in-service settings. Educator outcomes will be represented in changes in practices (e.g., the adoption or greater use of teaching techniques that encourage student engagement with science inquiry or engineering design); subject-matter or pedagogical content knowledge to increase; or increases in teacher efficacy. Educator outcomes might potentially include a rise in student engagement in STEM courses or the formation of a STEM-related identity among pupils.
Outcomes for Students:

- Learning and achievement,
- 21st century competencies,
- STEM course taking, educational persistence, and graduation rates,
- STEM-related employment,
- STEM interest, development of STEM identity,
- Ability to transfer understanding across STEM disciplines.

Outcomes for Educators:

- Changes in practice,
- Increased STEM content knowledge and pedagogical content knowledge.

2.4.2.3. Nature and Scope of Integration. Honey, Pearson and Schweingruber (2014, p.41) defines the elements that establish the nature and scope of integration as:

- type of STEM connections,
- disciplinary emphasis, and
- planning of STEM activities.

In terms of the nature of the connection, integrated STEM education may combine concepts from variety of disciplines in STEM fields (e.g., mathematics and science, or science, technology, and engineering); it may combine a subject from one discipline to a practice in another, such as applying geometric shape properties (mathematics) to engineering design; or it may connect two practices, such as scientific inquiry (e.g., conducting an experiment) and engineering (in which data from a science experiment can be applied).

One STEM discipline often plays a prominent role in integrated STEM education. The explicit or implicit aim of a project, program, or school is to improve students' knowledge or skills primarily in one main subject, such as mathematics. Incorporating concepts or methods from other disciplines is frequently done to aid or enhance learning and comprehension in the subject in the target. Integrated STEM education programs include a wide range of scope characteristics, including duration, setting, size, and complexity. Initiatives can take the form of a single hour-long project, a multi-class period project, or the organizing of a single course, a multi-course curriculum, or a whole school.

2.4.2.4. Implementation. A variety of factors can be evaluated in the implementation of STEM education. Honey, Pearson and Schweingruber (2014, p.43) underlies 3 aspects of STEM education for the implementation process as;

- instructional design,
- educator supports, and

- adjustments to the learning environment.

In terms of the instructional design, the programs use a variety of ways to teaching process, ranging from traditional, highly organized direct instruction to more student-centered, highly interactive, and open-ended techniques, which frequently featured problem-based learning variations.

This conceptual framework makes it more evident that integrated STEM education is about more than just combining the STEM disciplines. It is typically built on project- and problem-based learning, student-centered pedagogy, and transferable skills for the twenty-first century. It encourages students to be active learners by encouraging them to be original, creative, and critical thinkers (Shernoff, *et al.* 2017).

2.5. The Role of STEM Education Conception

The theoretical aspect behind how human beings develop ideas or construct concepts relies on their perception and what they perceive (Nespor, 1987). The perception of a human being is affected by various parameters such as previous experiences, knowledge and observation or the type, quality and source of the received information (Goodman, 1988).

In the field of education, the conception of teachers can lead pupils' learning processes to differ based on the implementation of a practice in the lesson. Teacher's understanding is one of the most important factors in the implementation of STEM education in classrooms (Fulton and Britton, 2011). Bell (2016) indicated how the perception of STEM education, personal knowledge about STEM education and comprehending what is known about STEM education intrinsically relate to effectiveness of STEM delivery during one's professional classroom practice. Educating pupils for STEM literacy can be ensured by teachers supported by their community that foster finding new information about STEM education and finding new ways for enhancing learning.

Rockland *et al.* (2010) mentioned that where subject knowledge of teacher is limited and their pedagogical application of that knowledge is also insufficient, the potential for pupil learning is restricted. This statement indicates that the knowledge of an educator is crucial as well as their pedagogical knowledge. The quality and content knowledge base of K–12 instructors, as well as their understanding of how to combine STEM disciplines, must be improved in order to establish effective STEM education programs (Honey, Pearson, and Schweingruber, 2014). However, there are obstacles in the way of integrating STEM education in practice. Specifically, existing STEM teachers being hesitant to use STEM education and materials in their classrooms cause STEM education methods not to be adopted properly (Nadelson *et al.* 2013). Similarly, they discovered to have just the most basic understandings of STEM education. This might be disadvantageous for the students to understand STEM concepts as well as it is to the educators to adopt STEM teaching methods (Magnusson *et al.* 1999). Instructors and researchers who employ STEM education must comprehend what constitutes STEM education content and practices, as well as what STEM education concepts include. All of these are described differently in the literature, particularly the conceptions of STEM education (Breiner *et al.*, 2012).

STEM is generally perceived as a traditional course of study that lacks an integrated approach. As a result, the most essential current definition of STEM education may be the concept of integration that is, STEM is the deliberate integration of multiple disciplines as they are applied to solve real-world issues (Sanders, 2009). The different disciplines of science, technology, engineering, and mathematics are viewed as one unit in STEM education approach, and the integrated disciplines should be taught as one coherent unit by STEM professionals who needs to be less prone to compartmentalize disciplines. Despite the fact that "real-life" STEM application is organically integrated, most K-12 classroom teachers do not teach the topic in this manner (Breiner, Harkness, Johnson and Koehler, 2012).

STEM educators must adapt innovative methods from the disciplinary approaches they were trained for in such a complex and demanding educational system. To organize real STEM projects for their pupils, STEM instructors would need to have both content expertise and professional characteristics (Morrison 2006). Teachers must have good content knowledge as well as pedagogical competence in order to be effective. STEM instructors, for example, need transdisciplinary expertise from many STEM fields as well as a unique set of pedagogical methods to create and implement a comprehensive STEM focused curriculum (Sanders, 2009). Most instructors, on the other hand, have only undergone training in one discipline, and most schools and classrooms at all levels still maintain distinct STEM departments and class hours (Honey *et al.* 2014).

In order to advance STEM education experiences in their schools, STEM educators must comprehend the concepts, the philosophy, and the goals that an integrated STEM approach implies (Breiner *et al.* 2012). STEM education exposes a variety of expected set of responsibilities for educators. A STEM teacher's responsibilities include integrating curriculum design and execution, connecting classroom activities to the real world, and focusing on innovation and application (Morrison, 2006). STEM education might become a simplified form of "design cycles" centered on hands-on activities that lack strong science and mathematics content if STEM educators do not understand how to implement the vision of integrated STEM education (Williams 2011). Teachers are quite unsure of how to teach STEM using integrated strategies like problem-based or project-based learning, as well as how to implement STEM education while maintaining disciplinary integrity.

The fundamental issue of implementing integrated STEM education is to promote a solid conceptual and foundational comprehension of essential topics across many disciplines. Furthermore, constructivist pedagogies that include exploration and discovery may necessitate teacher training in both educational foundations and science-focused ideas, as well as pedagogical knowledge (Stohlmann *et al.* 2012). Teacher efficacy, which has been demonstrated to be particularly critical for effective teaching, is also influenced by the conception of a teaching concept (Stohlmann *et al.* 2012). Having a well-informed view of STEM education will not only help instructors teach STEM disciplines using integrated ways, but it will also help them grow more comfortable teaching in this manner before they ever attend the classroom. To create a better-informed instruction in professional development, we need to learn more about how instructors presently conceptualize STEM education. (Radloff and Guzey, 2016).

Kepes (1995) mentioned how the visualizations carry so much information and they are the power to one's understanding. It is underlined that visual languages are more capable of conveying facts of opinions rather than any other means of communication. For a visual to become data, recorded process of visualizations need to be interpreted and manipulated in order to gain information from someone's cognition occurring in the brain (Finson and Pederson, 2011). Esrock (1994) stated that the image schemas of individuals are important to reveal the perception and structure of knowledge in cognitive level. Because of those reasons, it is important to use assessments that includes drawings to assess the conceptualizations.

Bybee (2013) provides nine different representations of STEM education that STEM practitioners might use. These perspectives range from considering "STEM" as a single topic or field at the end of one spectrum to viewing STEM as entirely transdisciplinary or more related with its real-world application on the other end of the spectrum. The perspectives of Bybee (2013) can be used to assess the drawings of individuals in order to gain insight about their conception of STEM education.

2.5.1. STEM Perspectives of Bybee

The model that was developed by Bybee (2013) underlies STEM education perspectives that were developed based on many discussions, articles, reports, and projects. Bybee (2013) graded nine different accepted models for the integration of STEM disciplines from a single discipline to integrated STEM education (Bybee, 2013; pp.74-79).

(i) **STEM Equals Science (or Mathematics).** In this first perspective as seen in Figure 2.4, STEM stands for science and, on rare occasions, a specific subject such as physics or biology. The multiple disciplinary orientations contrasting with the one discipline reference making this use of STEM particularly confounding. The referent may in certain situations be a field other than science or mathematics, such as engineering design.

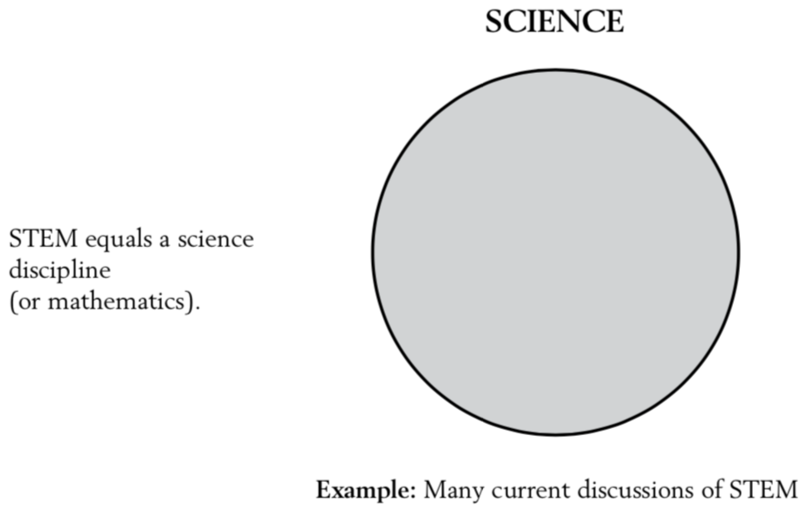


Figure 2.4. Single-Discipline Reference (Bybee, 2013, p.74).

(ii) **STEM Means Both Science and Mathematics.** STEM education can refer to both science and mathematics in some circumstances as seen in Figure 2.5. Due to the long history of these two fields as curricular components in education, this viewpoint should come as no surprise. Individuals refer to the distinct fields of disciplines as silos in certain STEM debates. There are silos and post holes in this view. The silos are obviously visible, and the postholes are apparent to some extent, but the essence of a hole is that it contains nothing; it is empty space. It means that the disciplines science and mathematics dominate the STEM education in some views that undermines the integration of engineering and technology.

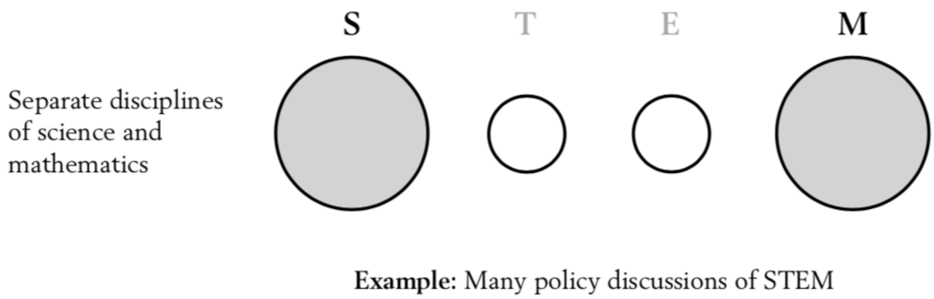


Figure 2.5. STEM as a Reference for Science and Math (Bybee, 2013, p.75).

(iii) **STEM Means Science and Incorporates Technology, Engineering, or Mathematics.** Some science instructors include technology and engineering elements in their lessons. Dropping egg from a certain height is a classic example of engineering and design challenges introduced by instructors. Unfortunately, engineering design is frequently conflated with science techniques. This perspective reflects the initial step toward integration of STEM disciplines, but the instructor retains science (or mathematics) as the dominating field and introduces the other disciplines when it is appropriate or necessary. This perspective as seen in Figure 2.6, can take on a variety of forms in a school context such as science incorporating technology, mathematics or engineering.

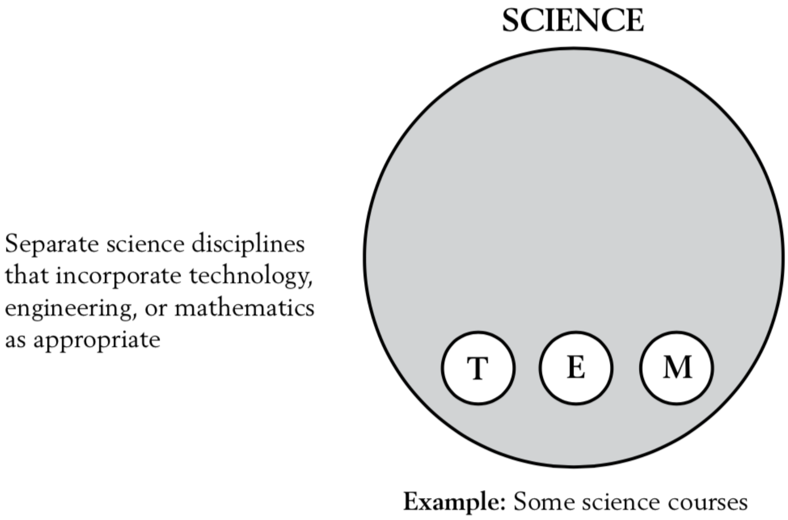


Figure 2.6. Separate Science Disciplines That Incorporate Other Disciplines (Bybee, 2013, p.75).

(iv) **STEM Equals a Quartet of Separate Disciplines.** In this perspective as seen in Figure 2.7, STEM refers to science, technology, engineering, and mathematics, all of which are covered in school with having a curriculum for each discipline. In some schools, technology is included in the curriculum as information technology and engineering as technology-design. But as in the metaphor of silos, they exist as discrete disciplines. Although the disciplines seem equal, their weights in the program are not the same. This viewpoint might apply to four different courses or sections within a single course.

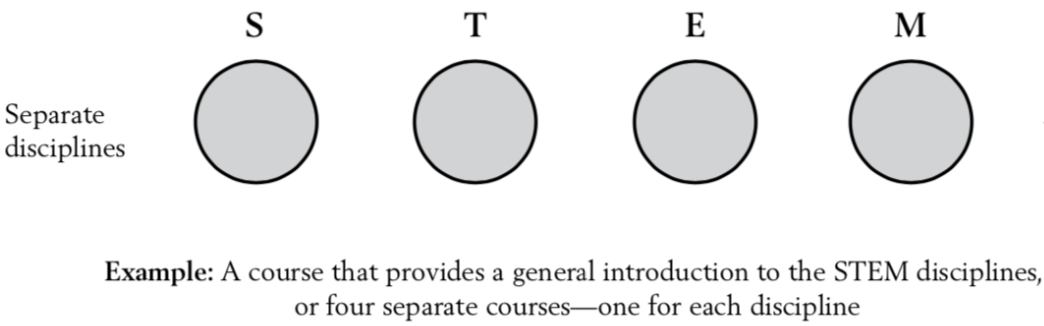


Figure 2.7. Separate Disciplines (Bybee, 2013, p.76).

(v) **STEM Means Science and Mathematics are Connected by one Technology or Engineering Program.** This perception as seen in Figure 2.8, includes science and mathematics as separate disciplines with the inclusion of a program that focuses on technology and/or engineering. A career and technical education program can be an example of this perspective. Technology and engineering projects are used to link the main subjects in the fields of science and mathematics in classes for the subjects of biomedicine, health sciences, energy resources or information technologies. It is assumed that science and mathematics are already a part of the educational curriculum. It is important to highlight that their relationship does not necessarily imply a coordination of the different disciplines' concepts and activities.

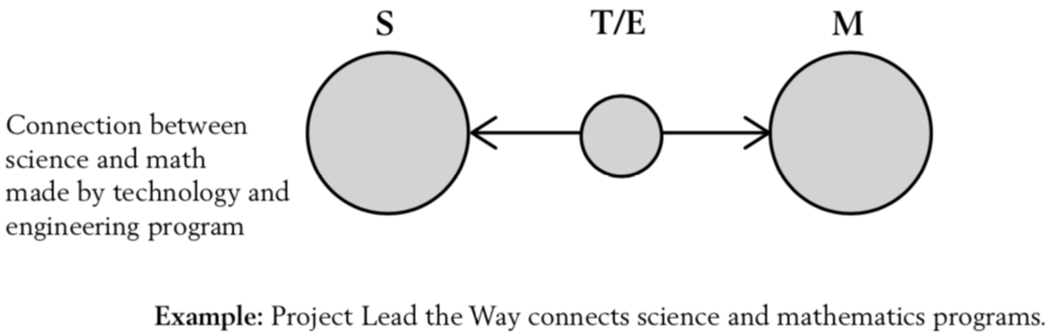


Figure 2.8. Science and Mathematics Connected by Technology or Engineering Program (Bybee, 2013, p.77).

(vi) **STEM Means Coordination Across Disciplines.** Mathematics teachers are frequently asked by science teachers to present principles in mathematics that will be used in science. Mathematics teachers are less likely to invite science or technology teachers to apply mathematics principles. However, concepts and procedures may be introduced and utilized across STEM fields in some circumstances. In reality, concepts and procedures will most likely be coordinated by two of the four disciplines as seen in Figure 2.9.

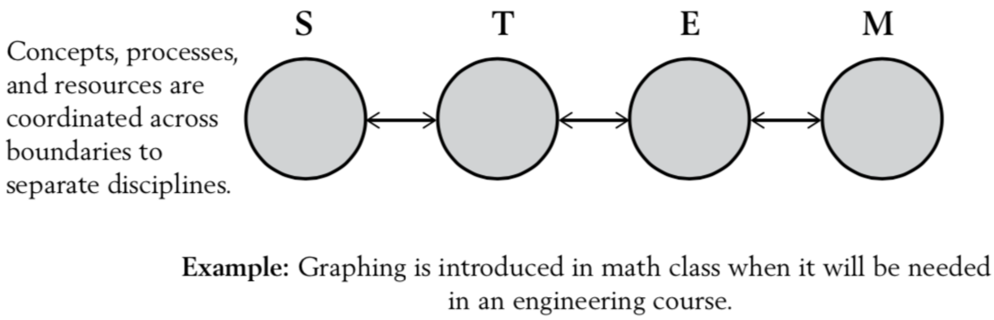


Figure 2.9. Coordination Across Disciplines (Bybee, 2013, p.77).

(vii) **STEM Means Combining Two or Three Disciplines.** Combining two disciplines as seen in Figure 2.10, such as science and technology or engineering and mathematics, is one way to start integrating. Three of the four disciplines are combined in a more complicated model. One example would be combining science, technology, and mathematics.

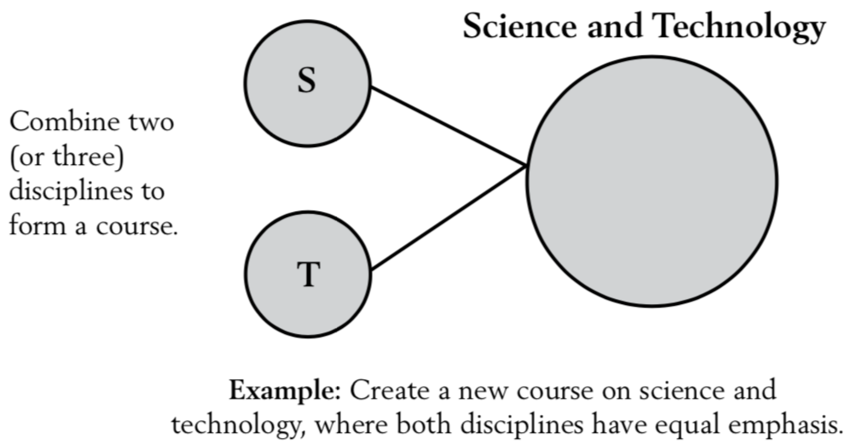


Figure 2.10. Combining Two or Three Disciplines (Bybee, 2013, p.78).

(viii) **STEM Means Complementary Overlapping Across Disciplines.** STEM may be integrated by arranging disciplines in units, courses, or lessons in such a way that STEM becomes a focal point of learning experience as seen in Figure 2.11. The possibility for overlapping STEM disciplines to arise during the process of seeking an answer for a scientific inquiry or the solving a design problem.

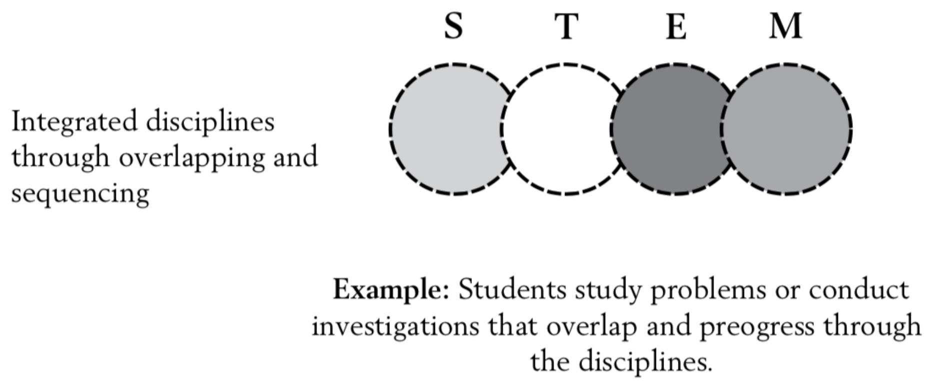


Figure 2.11. Integrated Disciplines (Bybee, 2013, p.79).

(ix) **STEM Means a Transdisciplinary Course or Program.** It is a STEM education perspective as seen in Figure 2.12 that adopts a transdisciplinary approach to important concerns such as global climate change, health difficulties, and energy consumption. A course named Sustainable Society, for example, may employ the variety range of STEM disciplines, as well as possibility of others (such as ethics, politics, and economics), to grasp a current key problem.

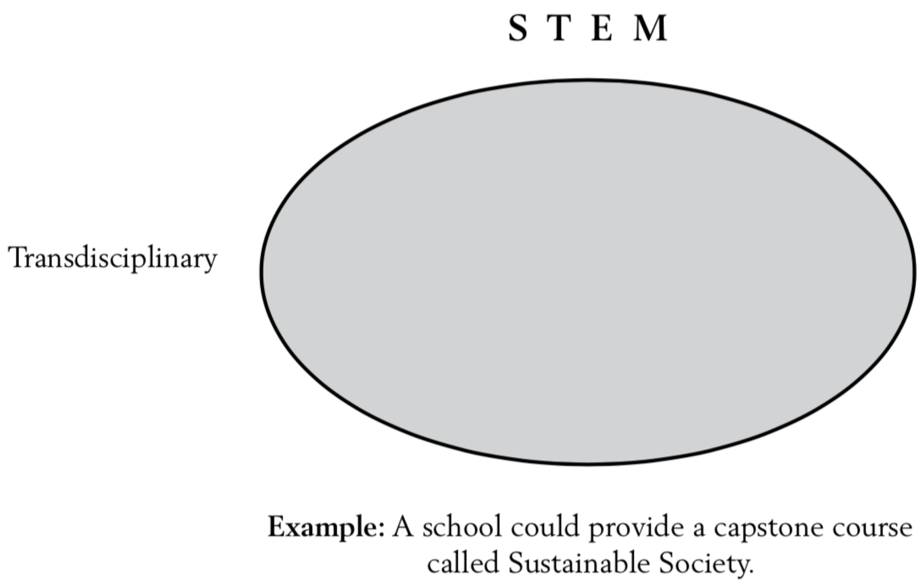


Figure 2.12. STEM as a Transdisciplinary Course or Program (Bybee, 2013, p.79).

2.6. Relation of Self-Efficacy and Conception of STEM Education

One of the important factors in social learning theory is the idea of self-efficacy beliefs. Albert Bandura's (1977) social learning theory emphasizes the significance of observing, modeling, and mimicking others' behaviors, attitudes, and emotional reactions. Individual actions are created as a function of the individual's environment, mental ability, and self-efficacy beliefs, according to social learning theory (Kiremit and Gökler, 2010). According to Bandura (1986), one of the authors of social learning theory, self-efficacy is a trait that is useful in the construction of behaviors and the individual's own judgements about their capacity to organize and effectively complete the activities necessary to display a given performance. In the theory of Bandura (1995), self-efficacy belief is introduced in the context of an explanatory model of human behavior, in which self-efficacy causally impacts predicted behavior outcomes, but not the other way around. Cognitive, motivational, emotional, and decisional processes are all affected by self-efficacy beliefs. Individuals' self-efficacy beliefs influence whether they think optimistically or pessimistically, and whether they think in self-enhancing or self-debilitating ways.

Based on Bandura's concept, Mccormick and Martinko (2004) endorsed self-efficacy and claimed that it can alter behavior and cognition in the following ways;

- choosing an activity,
- setting goals,
- effort and perseverance and
- learning and achievement.

According to Mark, Donaldson and Campbell (2011), individuals with high self-efficacy beliefs are more inclined to perceive challenging activities as something to master rather than something to avoid, whereas people with low efficacy are more prone to avoid demanding tasks and instead focus on personal inadequacies and negative outcomes. The notion of self-efficacy emerges as one of the main aspects that should be stressed in education from this perspective.

Teacher self-efficacy is described as a teacher's belief in his or her ability to plan and carry out the steps necessary to achieve desired outcomes. Teacher self-efficacy is a motivational concept that represents instructors' competency perceptions for teaching tasks in the future. It is the degree to which instructors believe they will be successful in their teaching tasks (Pfitzner-Eden, Thiel and Horsley, 2014). Several studies have shown a link between instructor self-efficacy beliefs and student achievement. In their article, Caprara *et al.* (2006) concluded that teacher's self-efficacy beliefs have significant contribution on student's achievement levels and job satisfaction of teachers. Self-efficacy beliefs of teachers were also associated with the enhancement of positive attitudes in classes, advance of self-esteem, increase in student motivation and students' self-efficacy beliefs. In addition, high levels of self-efficacy beliefs of the teachers promote establishment of the right condition in order to develop interpersonal networks, eventually leads them to sustain their satisfaction with their choice of profession. Caprara, Barbaranelli, Steca, and Malone (2006) found that students of highly effective instructors with high self-efficacy beliefs performed better and were more motivated than students of teachers with lower levels of self-efficacy beliefs. Given the link between teacher self-efficacy beliefs and student achievement, cultivating instructors with a high feeling of self-efficacy is an essential result for every teacher training program.

The self-efficacy of teachers is extremely important to achieve successful teaching. Self-efficacy in the context of teachers is considered as teachers' beliefs about their competencies for producing a desired impact on students' development and learning. For the account of teachers, the amount of knowledge in pedagogy and content have a large influence on their beliefs of self-efficacy (Stohlmann, Moore and Roehrig, 2012). Dicke et. al. (2015) suggested that knowledge may have large indirect beneficial impacts on self-efficacy, because teachers' professional knowledge is likely to lead to mastery experiences, which may increase instructors' self-efficacy beliefs.

Regarding the given information above, it could be concluded that self-efficacy beliefs is a crucial construct which could have indirect relation with conception in teaching STEM education. The possible relation between self-efficacy and conception of STEM education is required to be investigated to enhance practice. The different levels of self-efficacy beliefs of STEM education might be a good parameter to select participants to inquire variety of conceptions of STEM education. It could be significant to investigate the STEM education conceptions of participants who have different levels of self-efficacy beliefs in order to explore different aspects of STEM education conception.

3. SIGNIFICANCE OF THE STUDY

This study becomes prominent with its contribution to the science education research literature in four distinctive ways. The first property of the study is that it investigates STEM education conceptions of participants with different levels of self-efficacy beliefs. Improving the quality of STEM education integration in K–12 classrooms is dependent on teachers' related knowledge and beliefs (Ring et. al., 2017). It is very significant for STEM teachers to have a good command of knowledge and understanding in order to implement STEM education more effectively (National Research Council NRC, 2012). Özdemir, Yaman and Vural (2018) states that it is necessary for teachers to either have a detailed knowledge of STEM education or have done activities related to STEM education in order to have high self-efficacy beliefs about STEM education. Unfortunately, there is no research found in the literature that investigates participants' conception of STEM education depending self-efficacy belief. Given these premises, it would be an important contribution to reveal the conceptions of STEM education of the participants who have different levels of self-efficacy belief of STEM education in order to explore if the conceptions of participants have similarities or differences across the groups of participants having different levels of self-efficacy beliefs.

The second contribution of this study is that it includes STEM education researchers as participants including the researchers from the fields of science, mathematics and educational technologies. Researchers bear most of the responsibility for increasing values of STEM education in universities. Also, as teacher educators who train teachers, they should understand what STEM education is and what it constitutes. Without a doubt, researcher cannot teach what they do not comprehend. It is crucial to include teacher educators to investigate their conceptions of STEM education since teacher educators have a large effect on the perspectives of their students through pre-service and in-service trainings (Abdioğlu, Çevik and Koşar, 2021). To improve teacher education, researchers must first be extremely familiar with the STEM approach and understand its prerequisites and collaborate with other researchers from other disciplines. This study aims to provide the point of view from the STEM education researchers' perspectives.

The third part that the study contributes to the literature in terms of providing a comparison between STEM education researchers and STEM teachers including middle school science, mathematics and information technologies teachers with respect to STEM conception. Cross (2000) mentions that there is a gap between practitioners and researchers which can cause failing of classroom teaching leading poor learning of students. For this regard, researchers are criticized for not to communicate their research so that practitioners learn from them and apply the outcomes in their classroom. Especially, professional development workshops might fail to educate in-service teachers due to the reason that researchers have insufficient training to conduct productive effective teaching periods. In addition, Belli (2010) also states that on one hand, there are the researchers are concerned that practitioners are not reading or applying their study findings. They are focused on the requirements of quality academic research but are separated from the continuing issues of practice. Practitioners, on the other hand, are concerned with improving their practice but not with theoretical thinking and believe that study findings do not address actual problems and practical demands. Therefore, the comparison between STEM education researchers and STEM education teachers would supply great information in terms of the probable differences that may appear between these two groups.

The fourth and last, different aspects of middle school science, mathematics and information technologies teachers' actual perspectives will be revealed in terms of conceptions of STEM education. At this point, not only science teachers but also mathematics and information technologies teachers will be included in the study due to the reason that STEM education is interdisciplinary entity among discrete disciplines (Morrison, 2006). STEM education teachers including science, mathematics and information technologies teachers are expected to learn knowledge, skills, attitudes and teaching methods that are specific to another STEM discipline through learning communities that support inter-departmental cooperation (Akgündüz, *et al.*, 2015). Most educators lack the appropriate science, technology, engineering, and mathematics (STEM) content or pedagogical content competence to teach many subject areas at the same time (Zubrowski, 2002). As a result, collaboration among STEM instructors has the most promise in terms of applying integrative approaches. That supports the argument that STEM education can be applied successfully in classrooms as a consequence of comprehensive knowledge provided by STEM education teachers. Therefore, inclusion of not only science but also mathematics and information technologies teachers in the study would ensure a holistic approach from the STEM education teachers' conceptions of STEM education.

4. PURPOSE OF THE STUDY

The purpose of this study to examine; (a) the main features of the STEM education conceptions of STEM education researchers and middle school science, mathematics and information technologies teachers who get the score that is at least one standard deviation higher on the "Teacher Self-Efficacy Scale for STEM Practices" (TSESSP), (b) the main features of the STEM education conceptions of STEM education researchers and middle school middle school science, mathematics and information technologies teachers get the average score on the TSESSP, (c) the main features of the STEM education conceptions of STEM education researchers and middle school middle school science, mathematics and information technologies teachers who get the score that is at least one standard deviation lower than the average score on the TSESSP, (d) the main differences of the STEM education conceptions of STEM education researchers and middle school science, mathematics and information technologies teachers who got high, middle and low scores in in the TSESSP.

This study aims to assess the STEM education researchers' and teachers' self-efficacy beliefs of STEM education with a scale called "*Teacher Self-Efficacy Scale for STEM Practices*" (TSESSP) and assess the conceptions of STEM education by a questionnaire developed by the researcher based on the descriptive framework of Honey, Pearson and Schweingruber (2014), through conducting an interview.

In order to discover the unique characterizations in conceptions of STEM education, nine participants from both STEM education researchers and middle school STEM teachers were purposefully selected based on the scores obtained on the TSESSP. A questionnaire developed by the researcher was conducted through online interviews to investigate common features on the conceptions of STEM education researchers and middle school teachers constructed in their minds. The results of the comparison of STEM education conceptions between researchers and middle school teachers was used to evaluate to outcomes of TSESSP.

4.1. Research Questions

For the goal of examining and comparing the STEM education researchers' and middle school science, mathematics and information technologies teachers' conceptions of STEM education, this study is guided by the following research questions and those research questions:

1 How do STEM education researchers and middle school teachers conceptualize STEM education?

   (a) How do STEM education researchers and middle school teachers who get the score that is at least one standard deviation higher than the average score on the TSESSP, conceptualize STEM education?

   (b) How do STEM education researchers and middle school teachers who get the average score on the TSESSP, conceptualize STEM education?

   (c) How do STEM education researchers and middle school teachers who get the score that is at least one standard deviation lower than the average score on the TSESSP, conceptualize STEM education?

2 How does the conceptualization of STEM education differ or resemble for STEM education researchers who get different scores on the TSESSP?

3 How does the conceptualization of STEM education differ or resemble for middle school teachers who get different scores on the TSESSP?

4.2. Definitions of the Key Terms

In this study, there are 2 variables to be defined and operationalized namely STEM education conceptualization and teacher self-efficacy belief of STEM education. In addition, there are 7 terms to be defined namely STEM education, self-efficacy beliefs, conception, conceptualization, educational research, STEM education researcher, educational practice, STEM education teacher and practitioners.

STEM Education: "The approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning". (Kelley and Knowles, 2016, p.3).

Self-Efficacy Belief: "Beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p.3).

Teacher Self-Efficacy Belief: "Teacher's individual beliefs in their capabilities to perform specific teaching tasks at a specified level of quality in a specified situation". (Dellinger et.al., 2008, p.725).

In order to measure self-efficacy belief of STEM education, "Teacher Self-Efficacy Scale for STEM Practices" (APPENDIX A) developed by Özdemir, Yaman and Vural (2018) was utilized.

Conception: Mental representations that individuals employ to summarize observations and experiences that appear to have something in common, a complex product of processing and forming an understanding.

Conceptualization: The indicators that are used to investigate the dimensions of the concept. The process of clarifying what individuals mean using certain terminology.

STEM Education Conceptualization: The indicators that are used to investigate the dimensions of STEM education. In order to establish and investigate the dimensions of STEM education conceptions, the framework of "Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education" developed by Honey et al. *(2014) was used in this study. Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education consist of 4 dimensions namely goals, outcomes, nature and scope of integration and implementation.*

- *The first dimension, "goals", is divided into two sub-dimensions: student and practitioner goals. STEM literacy, 21st century competences, STEM workforce readiness, interest and engagement, and the ability to establish connections among STEM subjects are the goals for students (p.33). The aims for educators are increasing STEM content knowledge as well as pedagogical content knowledge (p.33).*
- *The second dimension, "outcomes", is divided into two sub-dimensions: student outcomes and practitioner outcomes. Learning and achievement, 21st century competencies, STEM course taking, educational persistence and graduation rates, STEM-related employment, STEM interest, development of STEM identity, and ability to transfer understanding across STEM subjects are all outcomes for students (p.38). Changes in practice, enhanced STEM content knowledge, and pedagogical content knowledge are the outcomes for educators (p.39).*
- *The third dimension, "nature and scope of integration", comprises the type of STEM connections, disciplinary emphasis, and initiative duration- size- complexity (p.41).*
- *The fourth dimension, "implementation", comprises instructional design, educator support, and learning environment adjustments (p.43).*

In order to investigate the STEM conceptions of the participants, "STEM Education Conceptualization Level Determination Interview Protocol" (APPENDIX B) developed by the researcher was utilized.

Educational Research: The structures, processes, products, and persons that are part of the systematic development of knowledge of education (Broekkamp and van Hout-Wolters, 2007).

STEM Education Researcher: An academic who have at least one publication about STEM education.

Educational Practice: The structures, processes, products, and persons that are directly involved in teaching in educational institutions, determination of local and central educational policies, and development of educational tools (Broekkamp and van Hout-Wolters, 2007).

STEM education teacher: A middle school science, mathematics or information technologies teacher who integrates STEM education in his/her classroom.

Practitioners: A person who professionally perform certain skills and teach related knowledge. In the study, practitioner is used to describe specifically the middle school science, mathematics or information technologies teachers who integrate STEM education in their classrooms.

5. METHODOLOGY

This chapter provides detailed information about the study's research methodology; research design, participants, instruments, data collection and data analysis.

5.1. Research Design of the Study

This study used qualitative research method to explore the STEM education researchers' and middle school teachers' conceptions of STEM education based on their self-efficacy levels of STEM education. Explanatory case study was the chosen as a research design since the study reviews the data extensively on both a surface and a deeper level in order to explain the data's phenomena for a purposefully selected participant groups based on their self-efficacy beliefs of STEM education (Zainal, 2007). In this study, participants were selected based on their TSESSP scores to gain a better grasp of the overall picture of the research problems by providing an investigation with interviews.

5.2. Participants

The data presented in the study was gathered from 2 different participant groups namely STEM education researchers and middle school teachers. The population of this study is that of all education researchers and all the middle school science, mathematics and information technologies teachers in Turkey. The target population of the study is all STEM education researchers and middle school science, mathematics and information technologies teachers that implement STEM education in their classes.

The participants of the study were selected by using purposive sampling that is also referred to judgement sampling which underlies the process of selecting participants from the population based on their deliberately identified criteria (Cohen, Manion, and Morrison, 2017). The identifying criteria for the two groups of STEM education researchers and middle school STEM teachers are different from each other for the purpose of the study. One of the criteria that is established for STEM education researchers, is to have completed a research study and published at least one peer-reviewed journal article, book chapter or a thesis in the field of STEM education. The other significant criteria for STEM education researchers were to be employed at a university in Turkey and had studied in one of the fields in science, mathematics and educational technologies. The identifying criterion for middle school STEM teachers was that if they have implemented or practiced STEM education in their classes. The teachers could be of any race, gender, age, years of teaching experience years or the grade levels they have been teaching. One of the critical aspects in this study was that the participants were selected based on their own statements of weather they practiced STEM education in their classes.

A total of 60 participants (30 participants from each group) were selected based on identified criteria for each group. Nine participants out of 30 were selected from STEM education researchers and 3 out of 10 participants were selected from each sub-group that are middle school science teachers, mathematics teachers and information technologies teachers based on their self-efficacy belief scores on "Teacher Self-Efficacy Scale for STEM Practices" (TSESSP). The mean of the total scores of each participant from the "Teacher Self-Efficacy Scale for STEM Practices" (TSESSP) were calculated in each sub-group and in STEM education researchers. The three participants from each subgroup were determined by using the distribution of the total scores including;

- one participant who got the score that is at least one standard deviation higher than the average score on the TSESSP,
- one participant who got the average score on the TSESSP, and
- one participant who got the score that is at least one standard deviation lower than the average score on the TSESSP.

For the group which consists of STEM education researchers, nine participants were selected by using the distribution of the total scores including;

- three participants who got the score that is at least one standard deviation higher than the average score on the TSESSP,
- three participants who got the average score on the TSESSP, and
- three participants who got the score that is at least one standard deviation lower than the average score on the TSESSP.

The Table 5.1 below shows the number of participants in each group and sub-groups for the quantitative and qualitative parts.

Table 5.1. The number of participants.

Number of the Participants	STEM Education Researchers	Middle School Teachers		
		Science Teachers	Mathematics Teachers	Information technologies teachers
Have taken TSESSP	30	10	10	10
Selected for the study	9	3	3	3

The study includes 2 main groups (STEM education researchers and middle school teachers) and 3 sub-groups under middle school teachers (science, mathematics and information technologies teachers). The participants were selected based on their self-efficacy belief scores on "Teacher Self-Efficacy Scale for STEM Practices" (TSESSP). The characteristics of each group are discussed in more detail below.

5.2.1. The Demographic Information of the Participants

5.2.1.1. The STEM Education Researchers. Thirty individuals who have been recognized as STEM education researchers was purposefully selected based on the criterion that is to have completed a research study and published at least one peer-reviewed journal article, book chapter or a thesis in the field of STEM education. STEM education researchers were selected through the websites called "*YÖK Akademik*" and

"*Google Scholar*". The key words such as STEM, STEM education, FeTeMM, FeTeMM eğitimi (in Turkish) were used to identify STEM education related scholarly articles, reports and books. The email addresses of researchers were found via YÖK Akademik or the articles. Each STEM education researcher was invited to this study through email including an invitation text attached with "*Participant Information and Consent Form*". The STEM education researchers who accept to involve in the study informed the researcher of this study through email. The group of STEM education researchers participated to this study from 19 different cities of Turkey including Alanya, Aksaray, Aydın, Erzurum, İstanbul, Diyarbakır, Erzincan, Eskişehir, Giresun, Karaman, Kırşehir, Kütahya, Muğla, Muş, Konya, Niğde, Ankara, Siirt, Sinop, Uşak.

Nine participants were selected from the group of 30 STEM education researchers. The participants were selected based on their scores on TSESSP including; (i) one SD higher than the mean, (ii) around the mean and (iii) one SD lower than the mean. The STEM education researchers who got the one SD higher than TSESSP were mentioned as A2, A21, A28 respectively, the STEM education researchers who got around the mean from TSESSP were mentioned as A7, A14, A24 respectively, and the STEM education researchers who got the one SD lower than TSESSP were mentioned as A9, A22, A25 respectively.

The Table 5.2 shows the demographic information of STEM education researchers who got a score one SD higher than the mean on TSESSP.

Table 5.2. Demographic Information of the STEM Education Researchers Who got a Score one SD Higher than the Mean on TSESSP.

	A2	**A21**	**A28**
Gender	Male	Male	Male
Age	40-49	40-49	30-39
Field of Study	Science Education	Mathematics Education	Educational Technologies
Academic Title	Assoc. Prof	Assoc. Prof	Assoc. Prof
Statue of Providing STEM Education Training	Yes	Yes	Yes
Number of Publication in STEM Education Area	10 or more	10 or more	10 or more

As it can be examined from the Table 5.2, the STEM education researchers who have provided training about STEM education before and got 10 or more publication related to STEM education had gotten one SD higher than the mean on TSESSP.

The Table 5.3 shows the demographic information of STEM education researchers who got a score around the mean on TSESSP.

Table 5.3. Demographic Information of the STEM Education Researchers Who got a Score Around the Mean on TSESSP.

	A7	**A14**	**A24**
Gender	Male	Male	Male
Age	40-49	40-49	50-59
Field of Study	Educational Technologies	Science Education	Mathematics Education
Academic Title	Professor	Assoc. Prof	Professor
Statue of Providing STEM Education Training	Yes	Yes	Yes
Number of Publication in STEM Education Area	10 or more	10 or more	5

As it can be examined from the Table 5.3, the STEM education researchers who have provided training about STEM education before and got 10 or more and 5 publication related to STEM education had gotten around the mean on TSESSP.

The Table 5.4 shows the demographic information of STEM education researchers who got a score one SD lower than the mean on TSESSP.

Table 5.4. Demographic Information of the STEM Education Researchers Who got a Score one SD Lower than the Mean on TSESSP.

	A9	**A22**	**A25**
Gender	Male	Male	Female
Age	30-39	40-49	30-39
Field of Study	Mathematics Education	Educational Technologies	Educational Technologies
Academic Title	Assoc. Prof	Assoc. Prof	Assoc. Prof
Statue of Providing STEM Education Training	No	No	No
Number of Publication in STEM Education Area	5	1	3

As it can be examined from the Table 5.4, the STEM education researchers who have not provided training about STEM education before and got 5, 3 and 1 publications related to STEM education had gotten one SD higher than the mean on TSESSP. Based on the demographic information of the STEM education researchers, their statue of providing STEM education training and the total number of publications in STEM education differed between the groups of STEM education researchers who got scores one SD higher / around the mean and 1SD lower on TSESSP.

5.2.1.2. The Middle School Teachers. This group of participants of the study was selected by using purposeful sampling. The researcher got in contact with one of the private institutions in Istanbul which provides STEM education training for in service teachers. The institution shared the contact information of the STEM education coordinator in one of the private schools which have many campuses in Turkey. The coordinator provided the names, surnames, email addresses and phone numbers of 25 middle school teachers including 10 science teachers, 10 mathematics teachers and 5 information technologies teachers who integrate STEM education in their classes. The teachers who satisfy the identified criteria received an e mail from the researcher that consist of invitation text attached with “Participant Information and Consent Form”.

Two of the information technologies teachers did not accept to involve in this study due to their schedule. Seven information technologies teachers were found from other private schools. The researcher of the study sent an email or called the coordinators of educational technologies departments at four different private schools to inform them about the study and the criteria for participants. The researcher sought for participants who volunteered for the study in order to guarantee desired representation of relevant sub-group within the sample.

Total number of 30 participants as middle school teachers including science teachers (N=10), mathematics teachers (N=10) and information technologies teachers (N=10) had taken "Teacher Self-Efficacy Scale for STEM Practices" (TSESSP). For the study, 3 participants were selected from each subgroup of middle school teachers. The participants were selected based on their scores on TSESSP including; i) one SD higher than the mean, ii) around the mean and iii) one SD lower than the mean. The middle school science, mathematics and information technologies teacher who got the one SD higher than TSESSP were mentioned as FO1, MO5, BO3 respectively, the middle school science, mathematics and information technologies teacher who got around the mean from TSESSP were mentioned as FO4, MO3, BO10, respectively, and the middle school science, mathematics and information technologies teacher who got the one SD lower than TSESSP were mentioned as FO3, MO1, BO9 respectively.

The Table 5.5 shows the demographic information of middle school science, mathematics and information technologies teachers who got a score one SD higher than the mean on TSESSP.

Table 5.5. Demographic Information of the Middle School Science, Mathematics and Information Technologies Teachers Who got a Score one SD Higher than the Mean on TSESSP.

	FO1	MO5	BO3
Gender	Female	Female	Male
Age	30-39	30-39	22-29
Field of Study	Science Education	Mathematics Education	Information Technologies
Total Years of implementing STEM education	5	5	1
Statue of Receiving STEM Education Training	Yes	Yes	Yes
In-service Training Format	seminar, training at the institution working at, online workshop, workshop, certificate program, online training, counseling from a teaching teacher, enrolled in a program related to STEM education, conference	training at the institution working at	seminar, training at the institution working at, certificate program, online training
Total Number of Inservice Training	1	4	1
The Date Inservice Training Received	2020	2017-2018	2021-2022
The Total Duration of Inservice Trainings	1 year	1 year	1 year

As it can be examined from the Table 5.5, the middle school teachers who got one SD higher than the mean on TSESSP had enrolled in a professional development program in the recent years and received 1 year of STEM education training. They also have been implementing STEM education in their classroom about 5 years except the information technologies teacher who have been implementing STEM education in his classroom for 1 year. The Table 5.6 shows the demographic information of middle school science, mathematics and information technologies teachers who got a score around the mean on TSESSP.

Table 5.6. Demographic Information of the Middle School Science, Mathematics and Information Technologies Teachers Who got a score Around the Mean on TSESSP.

	FO4	**MO3**	**BO10**
Gender	Female	Female	Female
Age	40-49	30-39	30-39
Field of Study	Education Science	Mathematics Education	Information Technologies
Total Years of implementing STEM education	3	2	4
Statue of Receiving STEM Education Training	Yes	Yes	I learned through my own research
Inservice Training Format	certificate program, online training	seminar, training at the institution working for. certificate program.	-
Total Number of Inservice Training	3	1	-
The Date Inservice Training Received	2019, 2020, 2021	2020-2021	-
The Total Duration of Inservice Trainings	3 weeks	1 year	-
The Resources of research	-	-	online videos, articles, consulting STEM teachers.
The Frequency of Research	-	-	As needed

As it can be examined from the Table 5.6, the middle school teachers who got around the mean on TSESSP had enrolled in a professional development program in the recent years except the information technologies teacher who learn STEM education through her own research. The teachers who enrolled in PD received 1 year and 3 weeks of STEM education training in total. They also have been implementing STEM education in their classroom about 4 to 2 years. The Table 5.7 shows the demographic information of middle school science, mathematics and information technologies teachers who got a score one SD lower than the mean on TSESSP.

Table 5.7. Demographic Information of the Middle School Science, Mathematics and Information Technologies Teachers Who got a Score one SD Lower than the Mean on TSESSP.

	FO3	**MO1**	**BO9**
Gender	Female	Female	Male
Age	40-49	30-39	30-39
Field of Study	Science Education	Mathematics Education	Information Technologies
Total Years of implementing STEM education	4	3	12
Statue of Receiving STEM Education Training	Yes	No	I learned through my own research
Inservice Training Format	seminar, training at the institution working for, online workshop, workshop, certificate program, online training	-	-
Total Number of Inservice Training	2	-	-
The Date Inservice Training Received	2016	-	-
The Total Duration of Inservice Trainings	10 hours	-	-
The Resources of research	-	-	online videos, research on the website, consulting with teacher friends., being a member of STEM education pages.
The Frequency of Research	-	-	As needed

As it can be examined from the Table 5.7, only one of the middle school teachers who got one SD lower than the mean on TSESSP had enrolled in a professional development program in 2016. The other middle school teachers who got one SD lower than the mean on TSESSP had learned STEM education through their own research. The teacher who enrolled in PD received 10 hours of STEM education training in total. The other middle school teachers who had learned STEM education through their own research, use different resources to research about STEM education as they need it. The teachers have been implementing STEM education in their classroom about 3 to 12 years.

5.3. Instruments

Two different instruments were used to investigate the purpose of this study which is examining the main features of the STEM education conceptions of STEM education researchers and middle school science, mathematics and information technologies teachers based on their self-efficacy beliefs levels of STEM education. Design of this study benefits from the use of qualitative data sources. The qualitative data source is the interviews based on “STEM Education Conceptualization Level Determination Interview Protocol (SECLDI)” developed by the researcher.

Regarding the participant selection based on self-efficacy beliefs levels of STEM education, only one instrument was used to collect data. Teacher Self-Efficacy Scale for STEM Practices was administered to STEM education researchers and middle school science, mathematics and information technologies teachers to determine outcomes of the selected aspect. The conception of STEM education was investigated through STEM Education Conceptualization Level Determination Interview Protocol including open ended questions, drawing a diagram to show how they visualize STEM education by using the letters S, T, E, M and explanation of diagram referring to STEM education. The study was conducted with 18 participants that were selected purposefully from the sample of the study including STEM education researchers and middle school science, mathematics and information technologies teachers.

5.3.1. Teacher Self-Efficacy Scale for STEM Practices” (TSESSP)

In order to identify the self-efficacy beliefs of STEM education researchers and middle school science, mathematics and information technologies teachers, Teacher Self-Efficacy Scale for STEM Practices (TSESSP) that was developed by Özdemir, Yaman and Vural (2018) was used in this study (APPENDIX A). This scale was prepared according to a 5-point Likert type and was graded as “Never (1), Rarely (2), Sometimes (3), Often (4) and Always (5)”. In the scale, 55 items were created at first, but the number of items was reduced to 18 after the necessary analyzes were made. The authors stated the reason why the items were removed from the developed scale was that there were overlapping items. The Cronbach Alpha internal consistency coefficient of the scale was calculated as .97. Exploratory factor analysis was applied to the scale and the suitability of the sample size was confirmed by KMO and Barlett statistics (KMO= .98, x2 = 208.3, p= .000). As a result of the exploratory factor analysis, only one sub-factor was reached, meaning that the scale is one-dimensional. The reason for this is related to the fact that the items of the self-efficacy scale are similar to each other.

The authors also applied the confirmatory factor analysis was applied to test the suitability of exploratory factor analysis. RMSEA, CFI, GFI and x2 coefficients applied in confirmatory factor analysis to confirm that the results obtained from exploratory factor analysis are at a satisfactory level. Accordingly, the Chi-Square value (X2 = 208.37, P=.000, N= 219) was found to be significant. The fit index values were found to be RMSEA= .05, NFI= .99, CFI= 1.00, IFI= 1.00, RFI= .98, GFI= .90 and SRMR= .025. As a result of the research, while there were 55 items in TSESSP, the number of these items was later reduced to 18 with the analyzes. The TSESSP consists of one sub-dimension and the Cronbach’s Alpha internal consistency coefficient is 0.97.

In addition, the TSESSP scores of pre-service teachers who have or do not have detailed knowledge about STEM education and pre-service teachers who participated and have not participated in the STEM-related training or professional development program were also compared by the authors, in order to contribute to the validity of the study.

5.3.2. STEM Education Conceptualization Level Determination Interview Protocol (SECLDIP)

The qualitative data resource is adapted by the researcher of this study. The opinions of two experts working in the field of STEM education were asked for the content validity whether the interview protocol fits for the purpose of the study and to administer it to middle school teachers and STEM education researchers in order to reveal their conceptions of STEM education. The interview protocol was adapted from the "Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education" published by Honey, Pearson and Schweingruber (2014) that includes 4 dimensions of STEM education including goals, outcomes, nature and scope of integration and implementation.

The STEM Education Conceptualization Level Determination Interview Protocol (SECLDIP) contains 2 parts including demographic information of the participants and STEM education conception level determination questions (APPENDIX B). The demographic information includes the name, surname, age, field of teaching, grades of teaching, total years of experience, the school of working/studying, e mail address, if they apply STEM / if they studied STEM and received training on STEM Education. STEM education conception level determination questions include 2 parts designed to evaluate STEM education conceptions of participants.

The descriptions of the open-ended questions are summarized in Table 5.8 on the next page.

Table 5.8. The description of the open-ended questions.

Questions	**The Dimension of the Question**	**Open-Ended Questions**
1^{st} Question	Definition	How would you describe STEM education in your own words?
2^{nd} Question	Goals	What are the goals of STEM education? a) For students b) For teachers
3^{rd} Question	Outcomes	What kind of outcomes can be observed in an education environment where STEM education is implemented? a) In terms of students b) In terms of teachers
4^{th} Question	Outcomes	What kind of changes have you observed in your classroom teaching practices after you started to implement STEM education?
5^{th} Question	Nature and scope of integration	What is the relationship between the disciplines involved in the STEM education activities you integrate? (what kinds of connections can be observed)
6^{th} Question	Nature and scope of integration	How complex should a STEM education activity be? (how long should it be applied)
7^{th} Question	Implementation	What kind of instructional design should be done before STEM education is implemented?
8^{th} Question	Implementation	Explain how disciplines are associated in the application of an activity that includes the linking of all disciplines in the STEM education.
9^{th} Question	Visualization	Now, I want you to visualize STEM education in your mind. What kind of model that you envision in your mind? Draw your model by using the letters S, T, E and M and showing the relationship between them:

The first part of the questions included textual questions. The second part of the questions includes a crucial part of demonstrating the understanding with visualization and modelling. The participants were asked to draw a visualization or a diagram of STEM education with using the letters S, T, E and M for each discipline in order to show the relation and connection. The visualization part was included intentionally to understand the conception of participants. With including the visualization part, the conception about STEM would be revealed in more detail that is accurate with the participants cognitive level of understanding of the phenomena (Buckley, 2000).

5.4. Data Collection

The data were collected after the necessary approval was received from Institutional Review Board for Research with Human Subjects of Boğaziçi University (APPENDIX C). Before the collection of data, the "*Participant Information and Consent Form*" was sent to the participants via email (APPENDIX D). The aim of the "*Participant Information and Consent Form*" is to protect participants' rights and notify participants about the purpose of the study including how the data they provided will be used. In addition, identities of all participants were protected by assigning them subject numbers; therefore, any name or information related to participants' identity remained private. In order to collect quantitative data, Google Forms link was sent to the participants who provided "*Participant Information and Consent Form*" with a signature.

5.4.1. Data Collection of TSESSP

Collection of the TSESSP from STEM education researchers and middle school science, mathematics and information technologies teachers regarding self-efficacy beliefs of STEM education was conducted through the tool of Google Forms because of the reason that the participants are from different regions of Turkey. TSESSP for collecting data was inserted to the Google Forms.

5.4.2. Qualitative Data Collection

After the collection of the TSESSP scores through Google Forms, the qualitative data was collected with the SECLDIP. The selected participants were invited to an online meeting in order to investigate the conception levels of the regarding group. To collect qualitative data, interviews were conducted through Zoom. The meetings were video recorded after the consent of the participants received. For the drawing visualization as it is included in the scale, the participants were asked to draw their visualizations on a piece of a paper and send it to the researcher via an email.

5.5. Data Analysis

In this section, the analysis of the data is detailed separately. The first sub-section contains information about the analysis of Teacher Self-Efficacy Scale for STEM Practices (TSESSP). The second sub-section contains information about the analysis of STEM Education Conceptualization Level Determination Interview Protocol (SE-CLDIP).

5.5.1. Data Analysis of TSESSP

Analysis of data from the TSESSP was done according to Özdemir, Yaman and Vural (2018) which the scale was taken from. The quantitative measurement tool TSESSP includes 18 items including only one dimension. This scale was developed according to the 5-point Likert type, "Never (1), Rarely (2), Sometimes (3), Often (4) and Always (5)". The participants' scores on TSESSP were shown in the APPENDIX E.

Each answer of the participants to TSESSP questions were given scores from 1 to 5 based on their answer. The total scores were divided by 18 the total question number to calculate TSESSP scores for each participant. After that, mean scores and standard deviations of each group were calculated. Descriptive results were examined and reflected for identifying minimum scores, maximum scores, mean, standard deviation values of STEM education researchers' and middle school teachers' scores on TSESSP. The means and standard deviations of each main group and sub-groups of middle school teachers have been investigated as a determinant process of participant selection.

The descriptive results of on TSESSP helped the researcher to infer the general trends in the STEM education researchers' and middle school science, mathematics and information technologies teachers' self-efficacy beliefs. The Table 5.9 provides mean scores (M), standard deviation (SD), minimum (min) and maximum(max) scores that STEM education researchers and middle school science, mathematics and information technologies teachers get from "TSESSP". From the Table 5.5.2, it can be seen that STEM education researchers got minimum and maximum scores 3.28 and 5.00, respectively, (SD= .478) with having mean of 4.309, middle school science teachers got minimum and maximum scores 3.44 and 5.00 respectively (SD= .617) with having mean of 4.272, middle school mathematics teachers got minimum and maximum scores 2,83 and 4,56 respectively (SD= .482) with having mean of 3.65, and middle school information technologies teachers got minimum and maximum scores 3.61 and 4.78 respectively (SD= .399) with having mean of 4.15.

Table 5.9. Descriptive Statistics Analysis of TSESSP scores.

GROUPS		**Statistic**	**Std. Error**
STEM Education Researchers	Mean	4.309	.087
	Std. Deviation	.478	
	Minimum	3.280	
	Maximum	5.000	
Middle School Science Teachers	Mean	4.272	.195
	Std. Deviation	.617	
	Minimum	3.440	
	Maximum	5.000	
Middle School Mathematics Teachers	Mean	3.650	.1525
	Std. Deviation	.482	
	Minimum	2.830	
	Maximum	4.560	
Middle School Information Technologies Teachers	Mean	4.150	.126
	Std. Deviation	.399	
	Minimum	3.610	
	Maximum	4.780	

Based on the mean scores and std. deviations of STEM education researchers' and middle school science, mathematics and information technologies teachers' scores on TSESSP, the 9 participants were selected from each group who got scores (i) one

SD higher than the mean, (ii) around the mean and (iii) one SD lower than the mean.

5.5.2. Qualitative Data Analysis

The qualitative data were collected through an interview with SECLDIP. The STEM education conception level determination questions have 2 parts which includes open-ended questions and drawing part. For the analysis of the open-ended questions, the answers of the participants were recorded and transcribed to conduct coding with using the "Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education" published by Honey, Pearson and Schweingruber (2014). The answers of the participants were coded at the first read. After the first reading and coding, the categories were organized to reveal the patterns in the thinking process of participants. By constantly comparing the responses of the participants to the particular questions, the final categories were more representative of the answers' actual intention. In addition, the coding was also done by a scholar in order to compare the codes and themes for internal reliability.

The Table 5.10, the Table 5.11, the Table 5.12, the Table 5.13 and the Table 5.14 shows all the codes, subcategories and categories under the themes of *definition, goals, outcomes, the nature and scope of integration* and *implementation* respectively.

Table 5.10. The examples of the codes under the *definition of STEM education* theme.

Theme	Category	Sub-category and Code	Example
Definition	Instructional aspect	Cooperation among field teachers	*"A21: That is why I see STEM education as a reflection of both the collaboration between teachers and the collaborations with outside experts"* (Cooperation among field teachers).
		Collaboration with experts	*"A21: That's why we aim to bring together experts who have this point of view"* (Collaboration with experts).
		Improve 21st century skills • Creativity • Critical thinking skills • Problem solving skills	*"A24: STEM education is an educational paradigm that emphasizes 21st century skill development, that is, in this context, this skill set such as creativity, problem solving, and critical thinking, and requires STEM fields to be employed while solving problems in an interdisciplinary way"* (Improve 21st century skills; creativity, critical thinking and problem solving).
		• Project design skills	*"FO3: At the same time, it is an education system that supports students in creating a project, teaches them how to create a project, how to create a project idea"* (Improve project design skills).
		• Skills • Knowledge	*"BO3: ...that nourish them both as knowledge and as skills"* (Increasing knowledge, Improving skills).
		• Innovative thinking • Analytical thinking	*"MO3: It is one of the most fundamental parts of education that connects mathematics to science and help students to develop innovative, analytical thinking"* (Improve innovative thinking, Improve analytical thinking).
		Including multiple tasks	*"A7: But when we come to the definition on the inside, multiple tasks can be included, multitasking skills will be transferred to both the teacher and the student"* (Including multiple tasks, improving skills).
		Real life problem solving	*"FO3: I would say to find solutions to daily life problems related to students' learning outcomes in lessons"* (Real life problem solving).
		Reinforce the learned topics Using different materials	*"MO5: In my opinion, it is to ensure that students are reinforced what they have learned by supporting them with different materials"* (Reinforce the learned topics, Using different materials).
		Produce something new	*"FO4: STEM education... To produce something new by combining technology, creativity and interests"* (Produce something new, Creativity).
		Product making	*"A9: Now, we can briefly define what we call STEM education as an approach in which more than one discipline is put to work and a product is produced at the end of the education process"* (Product making).
		Raising competent individuals	*"BO9: At this point, we can say that we are raising the future individual who has competence in every field"* (Raising competent individuals).
		Modelling	*"BO10: In other words, science, technology, engineering, mathematics, STEM [education] reveals itself. It is a modeling in which all these are together or a few of them together"* (Modelling).

Table 5.10. The examples of the codes under the *definition of STEM education* theme. (cont.)

Theme	**Category**	**Sub-category and Code**	**Example**
	Interdisciplinary nature of STEM education	Integration of art	*"A21: I'm adding art as well, I'm now adding STEAM [education]"* (Integration of art).
		Integration of disciplines	*"MO5: Let me put it this way, STEM [education] is actually a combination of many disciplines"* (Integration of disciplines).
		Integration of technology in lessons	*"A28: Since we look at it as the integration of technology to different fields"* (Integration of technology in lessons).
		Integration of social sciences	*"A14: I mean, it is possible to come together and solve one problem in disciplines including science, technology, mathematics and social sciences other than engineering, including art"* (Integration of social sciences).
	Theoretical aspect	Philosophical perspective	*"A21: I think it's a point of view, a philosophy even in disciplines' approach to the lesson"* (Philosophical perspective).
		• Progressivist perspective	*"A24: In other words, rather than as a teaching method, I am trying to define as a philosophical perspective to education, as a progressive perspective"* (Progressivist perspective).
		Educational approach	*"A2: I mean it as a teaching-learning approach"* (Educational approach).
		Educational program	*"A7: What can we say, a learning process, a curriculum that incorporates one or more disciplines into the work of an interdisciplinary study without destroying the essence of a main discipline"* (Educational program).
		Educational paradigm	*"STEM education is an educational paradigm that emphasizes 21st century skill development"* (Educational paradigm).
		Roof concept	*"A14: In general, this is actually a roof concept"* (Roof concept).

Table 5.11. The examples of the subcategories and the codes under the *goals of STEM education* theme.

Theme	Category	Sub-category and Code	Example
Goals	Regarding Students	Improve 21st century skills • Innovative thinking • Engineering skills • Self-expression skills	*"A2: 21st century skills, namely, to enable innovative thinking, to employ engineering skills or to transform them, high technological awareness or to raise leaders who can express themselves in society"* (Improve 21st century skills; innovative thinking, engineering skills, self-expression skills).
		• Problem solving skills • Critical thinking skills • Entrepreneurship skills • Social skills • Conflict resolution skills	*"A24: Some skills such as problem solving, critical thinking, and some long-term acquired skills, sometimes entrepreneurship can be included. For example, because the social environment includes group work, they also gain social interaction and social skills. For example, conflict resolution can be its by-products, l* et's say side effects, or *supporting skills"* (Improve 21st century skills; Problem solving skills, Critical thinking skills, Entrepreneurship skills, Social skills, Conflict resolution skills).
		• Transformative competencies	*"A7: So, whether these are 21st century skills or transformative competency, they are all interrelated"* (Improving 21st century skills; Improving transformative competencies).
		• Scientific thinking • Project design skills • Interdisciplinary thinking skills	*"FO3: I think it is to increase the ability to think scientifically, to develop projects, and to increase* interdisciplinary *thinking skills"* (Improving 21st century skills; Improve scientific thinking, improve project design skills, improve interdisciplinary thinking skills).
		Raising awareness for real life problem solving	*"A21: Basically, to raise awareness. Our goal is to raise individuals who can be good in every field as much as possible, with perspectives. I'm talking about a situation beyond what you say. I'm also talking about any situation in your life when you're looking for a solution to something new"* (Raising awareness for real life problem solving).
		Increase technology literacy	*"A28: The first of these is to increase technology literacy"* (Increase technology literacy).
		Being aware of real-life implementation of disciplinary concepts	*"FO3: Actually, this is one of the questions that students ask you the most in the course. Teacher, when are we going to use these things in our daily life? We can find the answer to this with STEM [education], and in fact, we can think of the solutions in the lessons. Whether it is in the curriculum or not, the things you experience in your daily life may suddenly come to your mind if you applied it in the class"* (Being aware of real-life implementation of disciplinary concepts).
		STEM workforce	*"MO5: I think that maybe children will reveal their hidden feelings in their career choices"* (STEM workforce).

Table 5.11. The examples of the subcategories and the codes under the *goals of STEM education* theme. (cont.)

Theme	**Category**	**Sub-category and Code**	**Example**
		Increase the awareness for societal issues	*"BO3: Recently, there is a consciousness and awareness towards social problems, and they have the opportunity to develop an idea, produce a project, follow it and turn it into a product, together with the lessons they take"* (Increase the awareness for issues of society, improve project design skills).
		Increase in motivation	*"MO5: It also helped me to motivate the children in class"* (Increase in motivation).
		Acquiring learning outcomes	*"FO3: The aim of STEM [education] for students, in my opinion, is to teach students the achievements in the curriculum with different methods"* (Acquiring learning outcomes).
		Raising competent individuals	*"A7: In other words, to be able to bring out qualified competent people or to reveal the people who will manage those competencies"* (Raising competent individuals).
		STEM literacy	*"A14: In other words, our aim in science education, of course, our most general aim is to raise science literate individuals. It is the same for mathematicians. It happens for those under technology as well as for those in engineering. We want to bring a literacy to individuals"* (STEM literacy).
		Gaining holistic perspective	*"A14: In other words, we can evaluate some approaches that we see on the basis of each discipline from a holistic perspective"* (Gaining holistic perspective).
		Permanent learning	*"A9: According to students, they will learn permanently"* (Permanent learning).
	Regarding Teachers	Improve 21st century skills • Engineering skills • Project design skills	*"A2: That's why I think STEM [education] is also important in terms of developing engineering skills and design skills in our teachers"* (Improve 21st century skills).
		Raising awareness for real life problem solving	*"A21: Even while watching a movie, I take notes and say that the scene in this movie shows very well what I'm going to do. Or you go somewhere, you see a worker's work, you bring it to your class. You watch a documentary, you see it, you address it in the class. In fact, it is necessary to have a change of perspective in order to draw in the existing things in life"* (Raising awareness for real life problem solving).
		Cooperation among field teachers Collaboration with experts	*"A25: In STEM studies, I think it is not very possible for a science teacher to design a STEM education. Because they need to come together with the eachers or researchers from different fields and design that process together for the most effective design"* (Cooperation among field teachers, Collaboration with experts).

Table 5.11. The examples of the subcategories and the codes under the *goals of STEM education* theme. (cont.)

Theme	**Category**	**Sub-category and Code**	**Example**
		Increase technology literacy	*"A28: Both students and teachers need to be able to use technology for sharing their work by integrating technology with the knowledge, to meet their needs, to be able to use it, to call it literacy, to achieve literacy"* (Increase technology literacy).
		Improving pedagogical content knowledge	*"A24: Or you know, the purpose of their profession is to bring students at a good level, that is, to provide quality learning. In this way, to develop the knowledge and skills that can make them more qualified in their profession, so they can reflect this to their students"* (Improving pedagogical content knowledge).
		• Developing perspective	*"FO1: I think the purpose of STEM [education] for teachers is to be able to explain the lesson from different perspectives, to use different methods and to develop their own point of view"* (Developing perspective).
		• Increase in productivity	*"MO5: It provided productivity"* (Increase in productivity).
		• Improving creativity	*"MO5: Here, I was able to adapt many things to my own lesson I used in my daily life which I did not realize before. It actually gave me creativity"* (Improving creativity).
		Increase in motivation	*"MO5: In this case, I motivated myself"* (Increase in motivation).
		Gaining engineering literacy	*"A14: Being able to look at things from an engineer's point of view can be considered as an opportunity for teachers to use a set of engineering skills or technical knowledge in STEM [education]"* (Gaining engineering literacy).
		Increase job satisfaction	*"A24: There may be such a professional satisfaction. That's what came to my mind"* (Increase job satisfaction).
		Gaining knowledge of other disciplines	*"BO10:" In other words, teaching is a part of learning. The more you produce, the more you learn. This is the biggest contribution to the teacher. So, a science teacher is learning to program, a mathematics teacher is learning to use technology"* (Gaining knowledge of other disciplines).

Table 5.12. The examples of the subcategories and the codes under the *outcomes of STEM education* theme.

Theme	Category	Sub-category and Code	Example
Outcomes	Regarding Students	Skill Outcomes • Language skills	*"FO1: Students can improve their language skills once"* (Improve language skills).
		• Self-management skills	*"A24: For example, students have to take responsibility for themselves. Therefore, we are talking about something where the students take responsibility for their own learning and gain a little more self-control"* (Self-management skills).
		• Analytical thinking	*"MO3: Their analytical thinking skills are developing"* (Improve analytical thinking).
		• Project design skills	*"A2: Once STEM [education] is engineering-based, design skills are improving"* (Project design skills).
		• Collaboration skills • Communication skills • Creativity • Problem solving skills	*"A25: In these 4 c fields, which we call collaboration, communications and creativity including problem solving"* (Collaboration skills, Communication skills, Creativity, Problem solving).
		Cognitive Outcomes • Spatial thinking • Imagination	*"A2: In addition to this, for example, skills such as 3D thinking, imagining, and editing develop when we look* at it in a cognitive sense" (Spatial thinking, Imagination).
		• Increase technology literacy	*"A 28: The first of these is technology literacy"* (Increase technology literacy).
		• Gaining holistic perspective	*"A14: In other words, we can evaluate some approaches that we see on the basis of each discipline from a holistic perspective"* (Gaining holistic perspective).
		• STEM literacy • STEM workforce readiness	*"A14: Of course, if we look at it in general, we say that children should be STEM literate individuals who will contribute to economic development"* (STEM literacy, STEM workforce readiness).
		• Being aware of real-life implementation of disciplinary concepts	*"A24: In other words, I think for both students and teachers, they have more ideas where the subject we deal with is useful, where it is used, in other words, what types of professions are related to that subject, where we encounter it in our lives, what scientists or engineers do about it"* (Being aware of real-life implementation of disciplinary concepts).
		• Increase academic achievement	*"A9: Apart from that, as we have just said, this will inevitably impact positively on the academic success of the students"* (Increase academic achievement).

Table 5.12. The examples of the subcategories and the codes under the *outcomes of STEM education* theme. (cont.)

Theme	Category	Sub-category and Code	Example
		Affective Outcomes • Motivation and engagement	*"A28: It is very clear that the students' motivation for the lesson increases. What we call academic engagement increases, students' time to deal with the lesson"* (Motivation and engagement).
		• Positive attitude	*"A2: In this context, I think that STEM [education] actually contributes to such courses [science, mathematics] in terms of positive attitude development as an affective outcome"* (Positive attitude).
		• Increase in self confidence	*"FO3: I have seen that students who do not just solve tests but produce things in a laboratory environment gain self-confidence"* (Increase in self-confidence).
		Psychomotor Outcomes • Operation of measuring tools	*"FO1: then they can use all their skills, from using measurement units to using rulers, I don't know, weight units to mass units"* (Operation of measuring tools).
	Regarding Teachers	Skills Outcomes • Transformative competencies	*"A7: In other words, one of the most important of these is being an entrepreneur,being innovative, I just called it transformative competencies because this is now how it is used, 21 century skills are not used anymore"* (Improving transformative competencies).
		Cognitive Outcome • Technology literacy • Engineering literacy	*"A2: I want them to create designs and products that will make these 2 data come to the fore, especially in the context of technology and engineering"* (Technology literacy, Engineering literacy).
		• Gaining knowledge of other disciplines	*"FÖ1: Since STEM [education] have interdisciplinary connections, you can interactively learn about outcomes of mathematics and technology, or even in a course you think has nothing to do with it. You can make decisions collaboratively with them"* (Gaining knowledge of other disciplines).
		• Being aware of real-life implementation of disciplinary concepts	*"A24: In other words, I think for both students and teachers, they have more ideas where the subject we deal with is useful, where it is used, in other words, what types of professions are related to that subject, where we encounter it in our lives, what scientists or engineers do about it"* (Being aware of real-life implementation of disciplinary concepts).
		• Developing perspective	*"FO4: It also improves our perspective"* (Developing perspective).
		Practical implications • Cooperation among field teachers	*"A7: Or acting in cooperation with other disciplinary teachers and inviting them to class if possible, or, if not, if the lesson is planned on a project basis, teachers should ensure that other disciplinary teachers takes place in that process somehow"* (Cooperation among field teachers).
		• Problem based teaching • Project based teaching	*"A14: Therefore, if teachers really use such project-based or problem-based learning approaches in classroom practices, it's called STEM [education]"* (Problem based teaching, Project based teaching).

Table 5.12. The examples of the subcategories and the codes under the *outcomes of STEM education* theme. (cont.)

Theme	Category	Sub-category and Code	Example
		• Collaboration with experts	*"A21: The second point is to reach experts. In fact, our expert potential is very high, when we think of parents"* (Collaboration with experts).
		• Student centered lesson	*"A24: After that, as a habit of student-centered education which will develop student behavior, teachers can gain a little more courage in this sense and give more space to such practices"* (Student centered lessons).
		• Integration of disciplines	*"BO3: Because it is the lesson they see in science, but they also do it in the computer class, and I taught them that lesson and they like it so much that the computer teacher tells them about science and try to turn it into a gamification, animation, or a coding activity with a program"* (Integration of disciplines).
		• Activity based teaching	*"FO4: I started to teach a little more activity-based lessons. I prefer activities"* (Activity based teaching).
		• Process oriented assessment	*''BO10: When you do a STEM [education] activity, you naturally make a process-oriented assessment, not a result-oriented one"* (Process oriented assessment).
		• Group works	*"FO3: You can see and observe students' different abilities because you are integrating the teamwork"* (Group works).
		• Questioning	*"FO3: I ask questions while teaching. I used to not ask questions"* (Questioning).
		Affective Outcomes • Increase in motivation towards teaching	*"A24: In such an environment, the teacher'sthe teacher's motivation towards teaching. In other words, it takes the satisfaction of the teacher to a slightly higher level"* (Increase in motivation towards teaching).
		• Increase in self confidence	*"A22: Obviously, a self-confidence increases in a person"* (Increase in self-confidence).
		Pedagogical content knowledge	*"A7: Teachers should also be good learners, they should cooperate with students, when they think their previous experiences which they actually tried to manage but could not do, they need to be able to manage all the contexts at the end, because of the need to manage the activities in which all these strategies, such as critical thinking, creative thinking for questioning. So, I wouldn't say they definitely acquire the competencies, there is a possibility of acquiring. If the teacher sees this need and develops himself in this field, it actually takes the student and the student to deepen"* (Improving pedagogical content knowledge).

Table 5.13. The examples of the subcategories and the codes under the *nature and scope of integration of STEM education* theme.

Theme	**Category**	**Sub-category and Code**	**Example**
The nature and scope of integration	Type of STEM connections	Connection of concepts to practice engineering and technology	*"A2: As I said, I think, engineering and technology are at the center, and science and mathematics surround it. They are interconnected, but I can say that they are intertwined"* (Connection of concepts from disciplines to practice technology and engineering).
		Each discipline as a different perspective	*"A21: Therefore, I think the relationship between disciplines can be described, not a subject relationship, but a perspective relationship"* (Each discipline as a different perspective).
		Connection of concepts from disciplines	*"FO1: In the field of mathematics and technology, there are connections, interdisciplinary connections. There are connections in the field of design. The design we will make is actually in the field of art. Because in order to keep the scale of the design, we connect it with mathematics in that aspect or we make a code software in it, we use the learning outcomes of technology. Or we paint it, trying to make an ergonomic design that is pleasing to the eye. We're using the art part. Or we add a pleasant music to our ears, to our design. Or we can actually connect with all kinds of disciplines"* (Connection of concepts from disciplines).
		Natural connection of disciplines in a real-life problem	*"A7: . . . when you approach a real-life problem, what are the disciplines should be included in it to solve it what we call content knowledge? You don't necessarily use a certain discipline, it's very simple. You add pedagogy later, now deal with content and knowledge"* (Natural connection of disciplines in a real-life problem).
	Planning of STEM activities	Complexity • Depends on grade level	*"A2: In this context, we can say that STEM [education] activity can be complicated and intensified according to the grade level"* (Depends on grade level).
		• Challenging	*"A21: It should be a complexity at the level of the classic zone of proximal development, it should be a challenge, it should be a challenging context, but it should not be something so difficult that they cannot reach, or they cannot do"* (Challenging).
		• Depends on the type of question	*"A7: But first you need to work on ill-defined problem to turn it into well-defined problem at the beginning"* (Depends on the type of question).
		• Depends on the real-life problems	*"BO9: First, it is necessary to go along the problems of daily life at the complex point. The student needs to interpret the solutions of a simple problem in daily life"* (Depends on the real-life problems).
		• Depends on the readiness level of the students	*"A7: Now the complexity here needs to be considered by level. At what level is the student, at what point, this variable should be considered"* (Depends on the readiness level of the students).
		• Simplified	*"A24: Especially at school age, such activities are made a little more understandable, but without losing that thing inside, without losing that essence, without losing that interdisciplinarity thing, its structure is purified from some unnecessary details in the simplest and mostunderstandable format as possible"* (Simplified).

Table 5.13. The examples of the subcategories and the codes under the *nature and scope of integration of STEM education* theme. (cont.)

Theme	Category	Sub-category and Code	Example
		• Depends on the content	*"A28: In other words, which branch of discipline will you be dealing with at the point of STEM education integration"* (Depends on the content).
		• Depends on the need analysis	*"A28: Designs cannot be made without a needs analysis"* (Depends on the need analysis).
		Duration and Size • Depends on the context	*"A21: The duration also completely depends on the context. Therefore, rather than such a period, it should be within a period of time in the context of the problem or project or product or idea you have set out to achieve"* (Depends on the context).
		• Depends on the question	*"A7: That's why, in order to give such a period of time, you must first be defining the STEM [education] activity there, but first you need to work on ill-defined problem to turn it into well-defined problem at the beginning. Because you don't know what you will spend until you switch from ill-defined to well defined"* (Depends on the question).
		• Depends on the project	*"A7: So, you are actually switching from problem-based learning to project based learning there. Well now, when you start with problem-based learning, you can't know the duration. But when you switch to project-based learning after you define your problem, you star the project management process. Yes, there is time"* (Depends on the project).
		• Depends on the product	*"A9: Now, STEM [education] is your activity... So, you actually have to decide on the product you are going to create"* (Depends on the product).
		• Depends on the readiness level of the students	*"A25: For example, the group that has received STEM-based education before and has no experience with it should be differentiated even if the activities to be done with the group are at the same grade level"* (Depends on the readiness level of students).
		• Depends on the grade level • Depends on the deepening	*"A14: As the class level increases, the complexity of those activities may increase as the knowledge there gains depth, that is, as the epistemological knowledge gains depth"* (Depends on grade level, Depends on the deepening).
		• Depends on the learning outcome • Depends on the engineering design	*"A2: The duration may vary depending on the complexity of the engineering design that we will acquire or employ, and it depends on the learning outcomes"* (Depends on the learning outcome, depends on the engineering design).

Table 5.13. The examples of the subcategories and the codes under the *nature and scope of integration of STEM education* theme. (cont.)

Theme	Category	Sub-category and Code	Example
		• Hour-based	*"FO4: In other words, if there were one lesson and two lessons every week, like a painting or music lesson, maybe the child would realize better what the STEM lesson is"* (hour-based).
		• Week-based	*"MO3: We usually give a period of 2 weeks to students. I give a 2-week period in these project studies, or sometimes 3-weeks, depending on the schedule of the students and the exam week"* (Week-based).

Table 5.14. The examples of the subcategories and the codes under *the implementation of STEM education* theme.

Theme	Category	Sub-category and Code	Example
The nature and scope of integration	Instructional Design	Lesson plan preparation	*"A2: In this context, it is necessary to make a more detailed lesson plan for STEM [education]"* (Lesson plan preparation).
		Deciding on teaching techniques and methods Deciding on practice	*"A2: Here, you can integrate which maybe another teaching-learning approach within the STEM approach. So, for example, are you going to do a project-based STEM [education] or a problem-based STEM [education] Or will it be done collaboratively, or will you do it with 5E at work"* (Deciding on teaching techniques and methods, Deciding on practice)
		Deciding on learning objectives	*"A21: Therefore, in this type of design, I suggest to teachers an instructional design, what are the subjects I want to talk about, want learning objectives I have in this time period"* (Deciding on learning objectives).
		Gaining attention	*"A21: Well, I know the students, what can be of interest to my students, that I can deal with these issues in a broader context"* (Gaining attention).
		Cooperation among field teachers	*"A21: I think it is necessary to come together with the teachers of these courses in mathematics, science, language and art, and I want to sit down and talk about this"* (Cooperation among field teachers).
		Front-end analysis • Deciding on a learning environment	*"A28: What achievements will I get, which class will I use, do I need a laboratory, do I need a classroom, do I need a smart board, do I need augmented reality, etc"* (Deciding on a learning environment).
		• Development of the instructional design	*"A28: We will move on to a design, we will design a methodology, a lesson"* (Development of the instructional design).
		• Implementation of instructional design	*"A28: After this design, we will apply an implementation to the students"* (Implementation of instructional design).
		• Evaluation of the instructional design	*"A28: After we did it, we saw that there are successes, then we will move on to the evaluation"* (Evaluation of the instructional design).
		Evaluation of student profiles	*"FO1: Is it suitable for the environment of this class, that is, the mood of this class? Is it practical or close to students' curiosity"* (Evaluation of student profiles)
		Arrangements of groups	*"FO1: How can I separate groups? How can students decide? To which occupational groups can I distribute students"* (Arrangements of groups)
		Deciding on materials	*"FO1: What materials can I use later, and which materials can I add"* (Deciding on materials)

Table 5.14. The examples of the subcategories and the codes under *the implementation of STEM education* theme. (cont.)

Theme	**Category**	**Sub-category and Code**	**Example**
		Deciding on the assessment	*"A14: There are teaching and learning methods on how to conduct this content, and then there is evaluation"* (Deciding on the assessment).
		Depends on the need analysis • content analysis • target analysis • task analysis	*"A14: I think we didn't say it, it's actually a need. What do we need or what does the student need in this situation"* (Depends on the need analysis) *"A25: Content analysis, target analysis, task analysis, it is actually a process that requires serious work."* (Need analysis; content analysis, target analysis, task analysis).
		Literature analysis Getting disciplinary expert's opinions	*"A24: In other words, in the activities developed by the experts, the determination of the needs, the literature analysis, expert opinions after the literature analysis are needed to be done"* (Literature analysis, Getting disciplinary expert's opinions).
		Evaluating the readiness level of students	*"BO10: I think a lot about the background of the students. In other words, can students do it, is their knowledge proficiency sufficient for this, is it at an adequate level academically"* (Evaluating the readiness level of students)?
		Deciding on the guiding instructions	*"FO4: Also, the instructions have to be precise"* (Deciding on the guiding instructions).
	Integration in Class	Student Centered • Integration of disciplinary concepts and skills around disciplinary practices	*"A7: Right now, there is a situation like this, if you think in STEM [education] logic, when you look at every engineering thing, I can bring you both science, technology and mathematics in an activity. I look at the event not only on the basis of the subject, but also with the skill set"* (Integration of disciplinary concepts and skills around disciplinary practices).
		• Integration of disciplinary concepts and practices around a product	*"MO3: In general, we enable students to come up with a product by doing group work in combining all disciplines"* (Integration of disciplinary). *concepts and practices around a product).*
		• Group work	*"MO3: We care about students' collaborative work while actually producing these products"* (Group work).
		• integration of disciplinary concepts and practices around a real-life problem	*"A2: What we care about in a STEM [education], where there must be a problem, is to use problem-centered engineering skills and come up with a product"* (Integration of disciplinary concepts and practices around a real-life problem).

Table 5.14. The examples of the subcategories and the codes under *the implementation of STEM education* theme. (cont.)

Theme	**Category**	**Sub-category and Code**	**Example**
		• Doing research	*"MO5: You know, in the STEM [education] project, we start with research about the subject, what kind of data are there"* (Doing research).
		• Brain storming	*"MO5: With a little brainstorming, of course, they research first, then we talk about it"* (Brain storming).
		• Creating discourse environment	*"BO3: We encourage them with questions that they can answer and actually create a discussion environment"* (Creating discourse environment).
		Teacher centered • Lecturing	*"BO3: While I am applying my own curriculum and applying my own STEM [education]lesson plan, I am explaining my own lesson outcomes"* (Lecturing).
		• Watching videos	*"MO5: Afterwards, I play videos about the subject for the students"* (Watching videos).
		Engineering Design • Testing of the prototype	*"A2: Especially in engineering design skill. After making the prototype, it is necessary to go to the testing phase"* (Testing of the prototype).
		• Re-designing of the prototype	*After testing the prototypes, if the children are on the right track, proceed accordingly. If there is a shift towards a wrong product, we need to remake the prototype"* (Re-designing of the prototype).
		Real size modeling	*"A21: We had the children draw with some chalk in the garden so that they could live. It's the size of a real Trex"* (Real size modeling).
		Activities extended to other disciplinary classes	*"A21: Students came from here, switched to art, switched to English, came back to me, switched to science"* (Activities extended to other disciplinary classes).
		Cooperation among field teachers	*"A9: I need to include other colleagues in the teaching process"* (Cooperation among field teachers).
		Real life application of disciplinary concepts	*"A21: For example, penguins' poop is pink, so it can be seen from space because of something they ate. For example, satellites from space show this. I want the teachers to say, "There is a penguin theme in the next class. This is the satellite you see; this is the satellite that takes the pictures of the penguins you will see" Like, it will go one step further to touch them as much as possible. We try to do them both by practicing physical relationships"* (Real life application of disciplinary concepts).

For the second part of the STEM education conception level determination questions, the visualizations were evaluated based on Bybee's (2013) theoretical "Perspectives of STEM Education". In his book, the chapter 8, "What is Your Perspective of STEM Education?" consists of Bybee's visual representations that individuals might develop to understand STEM education. The visualizations represent a spectrum that one side can be viewed as a single subject or discipline and the other side of the spectrum can be associated with its transdisciplinary real-world application.

The visualizations of Bybee (2013) were evaluated under 6 main categories as it is used in the literature (Radloff and Guzey, 2016; Ogan-Bekiroğlu and Caner, 2018). The names of the categories are; nested, transdisciplinary, interconnected, sequential, overlapping, and siloed. A conception of STEM education in which there was one overarching discipline was represented by nested representations. The focus on the real-world, application-based aspect of STEM education was proposed by *transdisciplinary* visualizations. This viewpoint also suggested a holistic approach to STEM. The *interconnected* visualizations featured connections that are drawn between all of the STEM fields. STEM education that is visualized as a series of or subsequent STEM disciplines closely followed each other, was grouped as *sequential* visualizations. Two overarching subjects were connected by "lesser subjects" in the category of overlapping representations. STEM has traditionally been taught in isolation in schools, as depicted by siloed visualizations. Each STEM field was linked but could also stand on its own.

The Figure 5.1 indicates the mental model examples that were drawn by the participants by using the letter S, T, E and M.

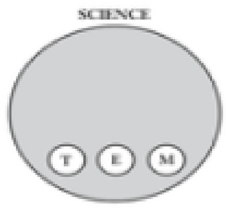
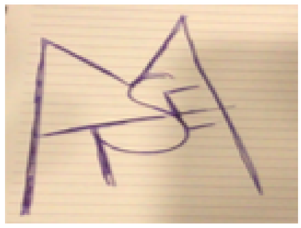
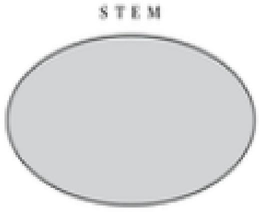
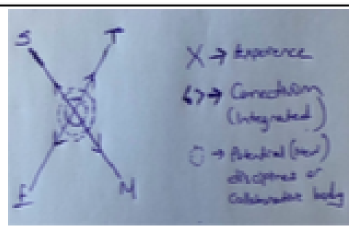
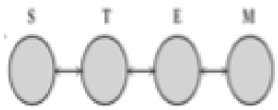
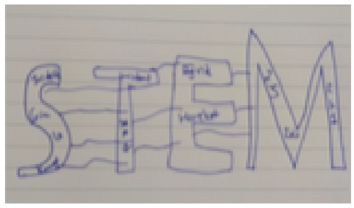
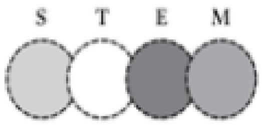
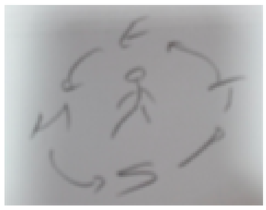
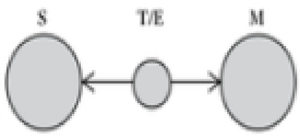
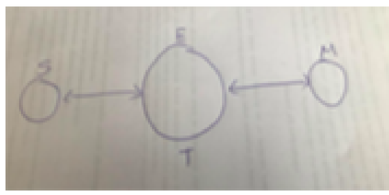
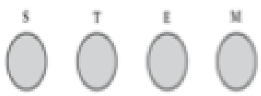
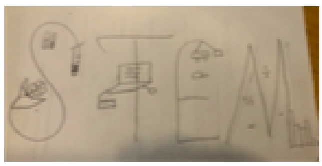
	Categories	Bybee's (2013) Visualizations	Examples
The Visualizations of STEM Education	Nested		
	Transdisciplinary		
	Interconnected		
	Sequential		
	Overlapping		
	Siloed		

Figure 5.1. The Mental Models of the Participants Under the *Visualization* Theme.

6. RESULTS

The findings of the qualitative data analysis are presented in this chapter. Qualitative results for STEM education researchers' and middle school teachers' responses to interviews which are based on "Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education". It covers the main themes and codes for sub dimensions of STEM education conception. At the end of the results part, the relationship between self-efficacy beliefs and conception of STEM education have been examined. In each part, STEM education researchers' and middle school teachers' conception of STEM education have been considered based on their levels of self-efficacy beliefs of STEM education.

6.1. Results of the Qualitative Analysis

In this part, the qualitative data results were examined first, through inductive and deductive open coding, and then thematic analysis. Inductive and deductive open coding which indicated that the constitution of the themes lies in either deriving from raw data itself (inductive coding) or obtaining from existing theoretical framework (deductive coding) (Joffe and Yardley, 2004). As a result, the researcher combined the two coding methods: the one approaches the data with predefined themes and categories drawn from existing theoretical framework, while the other is open to new ideas that might emerge. The use of quotes to highlight categories and themes keeps the analysis anchored in the facts. Deductive coding was used to determine the themes and categories for the questions 2, 3, 4, 5, 6, 7 and 8 while inductive coding was used to determine themes and categories of the question 1. All the subcategories and codes were determined by using inductive coding.

For the inductive coding, themes were notions that represent how the researcher perceived patterns in the data. So, from the codes emerged from data, categories were created, and from the categories formed, more comprehensive themes were created to represent the data in a way that summarizes it while preserving its complexity, depth, and context (Seers, 2012). For the deductive coding, themes were generated by partially using "Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education" published by Honey, Pearson and Schweingruber (2014) that includes 4 dimensions of STEM education including goals, outcomes, nature and scope of integration and implementation. However, the researcher was also aware of the other type of themes and categories emerged from codes of raw data for the questions 2, 3, 4, 5, 6, 7 and 8.

The results have been explicitly examined in accordance with answering research questions which were "How do STEM education researchers and middle school teachers conceptualize STEM education?", "How does the conceptualization of STEM education differ or resemble for STEM education researchers who get different scores on the TSESSP?" and "How does the conceptualization of STEM education differ or resemble for middle school teachers who get different scores on the TSESSP?". The quantitative data coming from SECLDIP helped to explain STEM education researchers' and middle school teachers' features of conceptions of STEM education.

6.1.1. The Inductive and Deductive Coding Analysis

In this part of the qualitative analysis, the researcher used inductive and deductive coding thematic analysis for the 9 questions in SECLDIP which were investigated under the themes of "Definition, Goals, Outcomes, Nature and Scope of Integration, Implementation and Visualizations". This part of the study aims to answer the first research question given as; "How do STEM education researchers and middle school teachers conceptualize STEM education?" The first research question includes 3 sub-questions that aim to investigate the groups in more detail.

6.1.1.1. The Analysis of the Research Question 1a. The research question 1a is "How do STEM education researchers and middle school teachers who get the score that is at least one standard deviation higher than the average score on the TSESSP, conceptualize STEM education?". The participants of STEM education researcher in this group got scores one SD higher than the mean on TSESSP (M= 4.309, SD= .478). The participant of middle school science teacher in this group got scores one SD higher than the mean on TSESSP (M= 4.272, SD= .617). The participant of middle school mathematics teacher in this group got scores one SD higher than the mean on TSESSP (M= 3.650, SD= .482). The participant of middle school information technologies teacher in this group got scores one SD higher than the mean on TSESSP (M= 4.150, SD= .399). The research question aimed to investigate the STEM education researchers' and middle school science, mathematics and information technologies teachers' STEM education conceptions. STEM education conceptions were examined under 6 main themes that includes *Definition* of STEM Education, Goals of STEM education, *Outcomes* of STEM education, *Nature and scope of integration* in STEM education, *Implementation* of STEM education and *Visualizations* of STEM education.

(i) **The Definition of STEM Education.** For the first theme, the interviews of STEM education researchers and middle school teachers who got a score one SD higher than the mean, examined one by one. The first question in SECLDIP aimed to collect answers for the *definition* of STEM education. It was seen that the participants touched on different and similar points in the categories determined below in each group. The Table 6.1 shows the categories determined by inductive coding and codes emerged for definition of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD higher than the mean.

Table 6.1. Categories and codes emerged for the theme of *definition of STEM education* for the groups who got a score one SD higher than the mean.

	Codes of STEM education	**Codes of middle school**
Categories	**researchers**	**teachers**
Instructional aspect	Cooperation among field teachers Collaboration with experts Real life problem solving	Improve 21st century skills • Improving skills • Increasing knowledge Real life problem solving Reinforce the learned topics Using different materials
Interdisciplinary nature of STEM education	Integration of art Integration of disciplines Integration of technology in lessons	Integration of disciplines
Theoretical aspect	Educational approach Philosophical perspective	Educational program

The answers of the first interview question were coded under the theme of definition. Based on the interviews of the participants, 3 categories were determined under the theme of *definition* by inductive coding. The categories include *instructional* aspect, *interdisciplinary nature of STEM education* and *theoretical* aspects. Although, the perspectives of STEM education researchers and middle school teachers were similar at some points (e.g. real-life problem solving and integration of disciplines), they differed at other perspectives. When the data was examined from the *instructional* category under *definition* theme, it was realized that STEM education researchers focused on Cooperation among field teachers and cooperation with experts form different professions. STEM education researchers underlined that STEM education could be implemented in the instructional settings as a product of collaboration of disciplinary teachers and as a product of cooperation with experts who works in STEM fields as professional workers. On the other hand, middle school teachers focused on improving skills, increasing knowledge and reinforce the learned topics. Middle school teachers defined STEM education as an instructional tool that can be implemented in the classroom setting to improve skills, increase knowledge and reinforce the learned topics in regular lessons. Both groups defined STEM education as real-life problem solving from the *instructional* aspect.

When we examined the data from the *interdisciplinary nature of STEM education*, it can be concluded that STEM education researchers gave importance to integration of art, disciplinary perspectives and technology in the STEM education. However, the middle school teachers did not mention any other point rather than the integration of disciplines under the *interdisciplinary nature of STEM education* aspect. The same pattern for both STEM education researchers and middle school teachers were discovered as integration of disciplines under the *interdisciplinary nature of STEM education* aspect. The codes that were driven under the theoretical aspect reflects that STEM education researchers focuses on the theoretical aspects as well as the other aspects. The codes show that STEM education was defined as educational approach and philosophical perspective while middle school teachers defined STEM education as an educational program. Middle school teachers defined STEM education as the integration of disciplines in a lesson program.

If the frequencies of STEM education researchers' data examined, it is observed that the code of *real-life problem solving* (f=3) emerged most frequently for the theme of *definition*. When the frequencies of middle school teachers' data examined, it is observed that the code of *integration of disciplines* (f=2) emerged most frequently for the theme of *definition*.

(ii) **The goals of STEM education.** For the second theme, the interviews of STEM education researchers and middle school teachers who got a score one SD higher than the mean, examined one by one. The second question in SECLDIP aimed to collect answers for the goals of STEM education. The goals theme has 2 main categories identified before the interview analysis. The categories include goals for students and goals for teachers. Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score one SD higher than the mean. The

Table 6.2 shows the categories determined by deductive coding, subcategories determined by inductive coding and codes emerged for goals of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD higher than the mean.

Table 6.2. Categories, subcategories and codes emerged for the theme of *goals of STEM education* for the groups who got a score one SD higher than the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Regarding Students	Improve 21st century skills • Improve innovative thinking • Use of engineering skills • Improve self-expression skill Increase technology literacy Raising competent individuals Raising awareness for real life problem solving	Improve 21st century skills • Improve problem solving skills • Improve project design skills Being aware of real-life implementation of disciplinary concepts Acquiring learning outcomes Increase technology literacy STEM workforce Increase the awareness for societal issues Increase in motivation
Regarding Teachers	Improve 21st century skills • Use of engineering skills • Improve project design skills Raising awareness for real life problem solving Cooperation among field teachers Increase technology literacy	Improving pedagogical content knowledge • Developing perspective • Increase in productivity • Improving creativity Increase technology literacy Increase in motivation Gaining knowledge of other disciplines

The second theme of *goals* were divided into two categories as *students* and *teachers*. The participants evaluated the goals of STEM education for both categories. The participants from both groups explained that STEM education improves 21st century skills and increase technology literacy. STEM education researchers also underlined that STEM education aims to raise awareness in each disciplinary perspective for real life problem solving and raise leader individuals. Middle school teachers, on the other hand, explained that STEM education aims to gain students awareness about the real-life implementation of disciplinary concepts, help students acquiring learning outcomes, increase motivation and increase awareness for social issues and discover their interest in STEM workforce. The middle school teachers differed from STEM education researcher in the points that STEM education is a tool to teach and practice the identified curricular objectives rather than to gain a perspective for real life problem solving.

In the second category of *teachers*, participants underlined that STEM education aims some of the same goals of students for teachers. Although, there is a same point (e.g. increase in technology literacy), the participants from both groups differed in some perspectives. STEM education teachers explained that STEM education aims to improve 21st century skills of teachers, increase the collaboration among disciplinary teachers, raising awareness in each disciplinary perspective for real life problem solving, being aware of personal inadequacies in other disciplinary expertise. Middle school teachers explained the goals for teachers as using different strategies, gaining holistic perspective and increase in productivity, creativity and motivation.

If the frequencies of STEM education researchers' data examined, it is observed that the codes of *improve 21st century skills* (f=3) and *increase technology literacy* (f=2) emerged most frequently for the theme of *goals for students.* When the frequencies of middle school teachers' data examined, it is observed that the code of *acquiring learning outcomes* (f=2) emerged most frequently for the theme of goals for students. If the frequencies of STEM education researchers' data examined, it is observed that the code of *raising awareness real life problem solving* (f=2) emerged most frequently for the theme of *goals for teachers.* When the frequencies of middle school teachers' data examined, it is observed that the code of *gaining knowledge of other disciplines* (f=2) emerged most frequently for the theme of *goals for teachers*.

(iii) **The Outcomes of STEM Education.** For the third theme, the interviews of STEM education researchers and middle school teachers who got a score one SD higher than the mean, examined one by one. The third and the fourth questions in SECLDIP aimed to collect answers for the goals of STEM education. The outcomes of STEM education theme had 2 main categories identified before the analysis of interview. The categories included the outcomes for students and goals for teachers. Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score one SD higher than the mean. Table 6.3 shows the categories determined by deductive coding, subcategories determined by inductive coding and codes emerged for *outcomes* of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD higher than the mean.

Table 6.3. Categories, subcategories and codes emerged for the *outcomes of STEM education* for the groups who got a score one SD higher than the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Regarding Students	Skill Outcomes • Project design skills Cognitive Outcomes • Spatial thinking • Improving imagination • Gaining holistic perspective • Increase academic achievement Psychomotor Outcomes Affective Outcomes • Increase interest in STEM disciplines • Gaining the attitude of different disciplines • Increase motivation and engagement	Skill Outcomes • Communication skills • Problem solving skills Cognitive Outcomes • Being aware of real-life implementation of disciplinary concepts Psychomotor Outcomes • Operation of measuring tools
Regarding Teachers	Cognitive Outcome • Technology literacy • Engineering literacy Pedagogical content knowledge Practical implications • Problem based teaching	Cognitive Outcome • Gaining knowledge of other disciplines • Technology literacy Pedagogical content knowledge • Creativity Practical implications • Student centered lesson • Problem based teaching • Integration of disciplines

For the third theme of *outcomes*, two categories were identified as *students* and *teachers*. When the codes of the participants examined, the patterns reveal that there are also sub-categories defined as *skill outcomes, cognitive outcomes, psychomotor outcomes and affective outcomes* under *student* category. For the teacher category, *pedagogical content knowledge and practical implications* were also created as sub-categories. There was an obvious difference between STEM education researchers and middle school teachers in terms of *student* category which is affective outcomes. The middle school teachers generally focused on the skills and the application process of activities which are problem-based projects. By this way, students can realize the connection of disciplines and realize the real-life applications. On the other hand, STEM education researchers also focused on those point by adding increase in motivation, engagement, interest of STEM disciplines, gaining attitudes of different disciplinary professions such as engineers. When the codes of the two groups examined under the *teacher* category, it is identified that middle school teachers mentioned more about the changes in the practice as an outcome, while STEM education researchers identified the outcomes focusing on content knowledge and pedagogical content knowledge.

If the frequencies of STEM education researchers' data examined, it is observed that the sub-category of *skill outcomes* (f=3) emerged most frequently for the theme of *outcomes for students*. When the frequencies of middle school teachers' data examined, it is observed that the sub-category of *skill outcomes* (f=3) emerged most frequently for the theme of outcomes for students. If the frequencies of STEM education researchers' data examined, it is observed that the code of *pedagogical content knowledge* (f=2) emerged most frequently for the theme of outcomes for teachers. When the frequencies of middle school teachers' data examined, it is observed that the code of *gaining the knowledge of other disciplines* (f=2) emerged most frequently for the theme of *outcomes* for teachers.

(iv) **The Nature and Scope of Integration in STEM Education.** For the fourth theme, the interviews of STEM education researchers and middle school teachers who got a score one SD higher than the mean, examined one by one. The fifth and the sixth questions in SECLDIP aimed to collect answers for the nature and scope of STEM education. *The nature and scope of integration* theme had 2 main categories identified before the interview analysis. The categories included *the relation between disciplines* and *duration, size and complexity of practice*. Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score one SD higher than the mean. In terms of *the nature of the connection, integrated* STEM education may bring together concepts from multiple disciplines (e.g., mathematics and science, or science, technology, and engineering); it may connect a concept from one subject to a practice in another, such as applying geometric shape properties (mathematics) to engineering design; or it may combine two practices, such as science inquiry (e.g., conducting an experiment) and engineering (in which data from a science experiment can be applied) (Honey, Pearson and Schweingruber, 2014, p. 42). Table 6.4 shows the categories and subcategories determined by deductive coding and codes emerged for the nature and scope of integration of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD higher than the mean.

Table 6.4. Categories, subcategories and codes emerged for the *nature and scope of integration of STEM education* for the groups who got a score one SD higher than the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Type of STEM connections	Connection of concepts to practice engineering and technology Each discipline as a different perspective	Connection of concepts from disciplines
Planning of STEM activities	Complexity • Depends on grade level • Challenging • Depends on the content • Depends on the need analysis Duration and Size • Depends on the learning outcome • Depends on the context • Depends on the need analysis	Complexity • Depends on grade level Duration and Size • Hour-based

For the theme of *the nature and scope of integration* of STEM education, two categories were identified as *type of STEM connections and planning of STEM activities*. For the first category of type *of STEM connections*, the participants differed in terms of their codes created based on their answers. Middle school teachers perceive the disciplines of STEM education as an integration of disciplinary concepts, while STEM education researchers indicated that STEM education is the Connection of concepts to practice engineering and technology, connection of concepts from disciplines to practice technology, each discipline as a perspective.

For the second category of *planning of STEM activities*, two subcategories were identified as *complexity and duration and size.* Middle school teachers explained that the complexity of STEM education activities depends on the grade level while STEM education researchers indicate that it depends on grade level, context, content and need analysis. STEM education researchers also explained that the practice needs to be challenging but at a level that students can understand and work on. For the *duration and size* subcategory, STEM education researchers avoided giving certain answers for the practice while indicating that it depends on learning outcome, context and need analysis. On the other hand, middle school teachers indicated that 1 class hour is not enough for the STEM activities and they need more class hours such as 3 or 4 hours in a week.

If the frequencies of STEM education researchers' data examined, it is observed that *Connection of concepts to practice engineering and technology* (f=2) for the theme of *types of STEM connection* emerged most frequently. When the frequencies of middle school teachers' data examined, it is observed that the code of *connection of concepts from disciplines* (f=3) emerged only code for the theme of *types of STEM connection.*

If the frequencies of STEM education researchers' and middle school teachers' data examined, it is observed that the code of *depends on the grade level* (f=2) emerged most frequently for the subcategory of *the complexity of STEM activities* for both groups. When the frequencies of STEM education researchers' data examined, it is observed that the code of *depends on the context* (f=2) emerged most frequently for the sub-category of *duration and size of STEM activities.* For that sub-category, teachers only indicated that 1 class hour is not enough for STEM implementation.

(v) **The implementation of STEM education.** For the fifth theme, the interviews of STEM education researchers and middle school teachers who got a score one SD higher than the mean, examined one by one. The seventh and eighth questions in SECLDIP aimed to collect answers for implementation of STEM education. *The implementation of STEM education* theme has 2 main categories identified before the interview analysis. The categories include *instructional design and integration in class.* Each category was discussed in more detail by giving specific examples from the responses of STEM education researchers and middle school teachers who got a score one SD higher than the mean. Table 6.5 shows the categories determined by deductive coding and subcategories by inductive coding and codes emerged for *implementation of STEM education* for the groups of STEM education researchers and middle school teachers who got a score one SD higher than the mean.

Table 6.5. Categories, subcategories and codes emerged for the *implementation of STEM education* for the groups who got a score one SD higher than the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Instructional Design	Lesson plan preparation Deciding on teaching techniques and methods Deciding on practice Deciding on learning objectives Gaining attention Cooperation among field teachers Evaluation of student profiles Front-end analysis • Deciding on a learning environment • Development of the instructional design • Implementation of instructional design • Evaluation of the instructional design	Lesson plan preparation Cooperation among field teachers Deciding on practice Evaluation of student profiles Arrangements of groups Deciding on materials
Integration in Class	Engineering Design • Testing of the prototype • Re-designing of the prototype Real size modeling Activities extended to other disciplinary classes Real life application of disciplinary concepts Integration of disciplinary concepts and practices around a real-life problem	Student Centered • Integration of disciplinary concepts and practices around a product • Brain storming • Creating discourse environment • Doing research Teacher centered • Lecturing • Watching videos

For the theme of *implementation*, two categories were identified as *instructional design* and *integration in class*. Although STEM education researchers and middle school teachers are similar at some points (e.g. lesson plan preparation, deciding on practice, Cooperation among field teachers and evaluation of student profiles), they became distinct at certain points. First of all, STEM education researchers explained the instructional design process step by step as deciding on a learning environment, development of the instructional design, implementation of instructional design, evaluation of the instructional design. On the other hand, middle school teachers explained the instructional process from a practitioner perspective such as arrangements of groups, arrangement of occupational groups and deciding on materials.

For the *integration in class* category, STEM education researchers explained that STEM education can be implemented to the classrooms with product making based on a real-life question, modelling and real-life application of disciplinary concepts. It is also indicated that the connection of disciplinary concepts can be achieved with activities extended to other disciplinary classes. Before STEM education implication need assessment is also an important factor in order to determine the way of integration. Middle school teachers, on the other hand, indicated that STEM education can be implemented and planned around a product and also including brain storming, creating discourse environment and doing research. Teachers also explained that there can be some lecturing and video watching during the implementation for students to understand the disciplinary concepts.

If the frequencies of STEM education researchers' data examined, it is observed that the codes of *lesson plan preparation* (f=2), *deciding on learning objectives* (f=2) and *deciding on practice* (f=2) emerged most frequently for the category of *instructional design.* When the frequencies of middle school teachers' data examined, it is observed that the code of *arrangement of groups* (f=2) emerged most frequently for the category of *instructional design.*

If the frequencies of STEM education researchers' data examined, it is observed that the codes emerged have the same frequency for the category of *integration in class.* When the frequencies of middle school teachers' data examined, it is observed that the code of *integration of disciplinary concepts and practices around a product* (f=3) emerged most frequently for the category of *integration in class.*

(vi) **The Visualizations of STEM Education.** For the sixth theme, the visualizations of STEM education researchers and middle school teachers who got a score one SD higher than the mean, examined one by one. The ninth questions in SE-

CLDIP aimed to collect answers from the participant about how they visualize STEM education. The *visualization* theme was categorized based on by Bybee (2013). The visualizations informed the researcher about the mental images of STEM education in participants cognitive understanding.

The visualizations of Bybee (2013) were evaluated under 6 main categories as it is used in the literature (Radloff and Guzey, 2016; Ogan-Bekiroğlu and Caner, 2018). The names of the categories are; nested, transdisciplinary, interconnected, sequential, overlapping, and siloed. The categories emerged for STEM education researchers were; overlapping (N=1) and nested (N=2). The categories emerged for middle school teachers were; interconnected (N=2) and siloed (N=1).

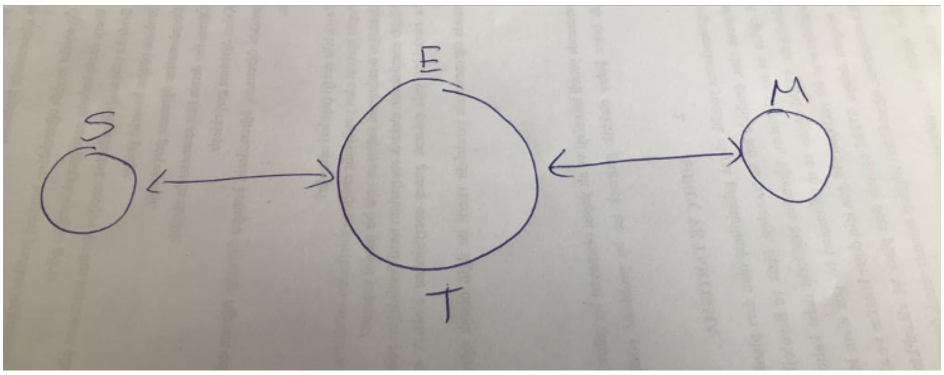


Figure 6.1. Visualization of A2 coded as *overlapping*.

The Figure 6.1 represent the visualization of participant A2, one of the STEM education researchers. The participant' purpose was to show that using engineering and technology as a tool, as a practice to integrate mathematics and science. The participant also added that this model is based on the experiences in the reality of Turkey. It can be concluded that the model falls in the *overlapping* category.

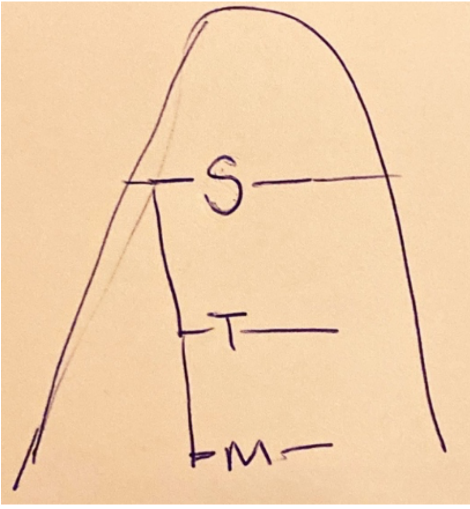


Figure 6.2. Visualization of A21 coded as *nested*.

The Figure 6.2 represent the visualization of participant A21, one of the STEM education researchers. The participant' purpose was to show that engineering is the driving force behind integrating science, mathematics and technology. It can be concluded that the model falls in the category of *nested*. All the disciplines including science, technology and mathematics are connected by engineering.

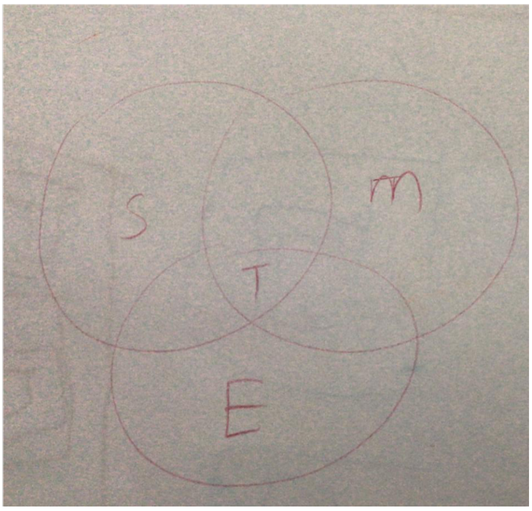


Figure 6.3. Visualization of A28 coded as *nested*.

The Figure 6.3 represent the visualization of participant A28, one of the STEM education researchers. The participant' purpose was to show that technology is the driving force integrating science, mathematics and engineering. It can be concluded that the model falls in the category of nested. The visualization is different from other visualizations in the category of nested, but the main purpose indicates that one of the disciplines, technology in this case, overarching discipline.

Figure 6.4. Visualization of FO1 coded as *interconnected*.

Figure 6.4 represent the visualization of participant FO1, one of the middle school teachers. The participant' purpose was to show that both disciplines interact with each other, they are separate from each other, but they also touch each other. It can be concluded that the model falls in the category of *interconnected*.

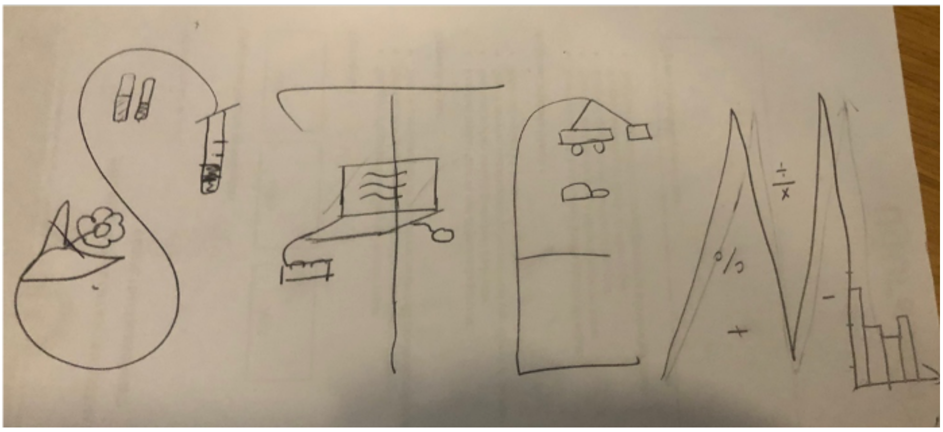


Figure 6.5. Visualization of MO5 coded as *siloed*.

Figure 6.5 represent the visualization of participant MO5, one of the middle school teachers. The participant' purpose was to show that both disciplines are separated as a discipline. It can be concluded that the model falls in the category of *siloed*.

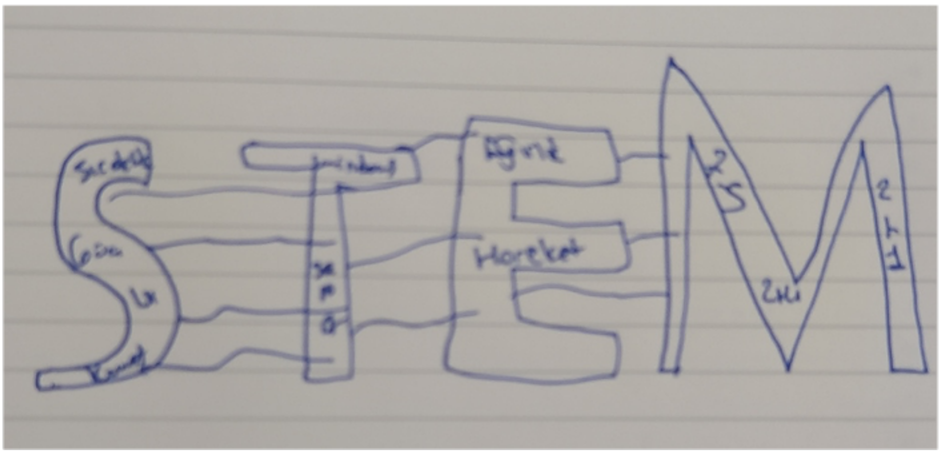


Figure 6.6. Visualization of BO3 coded as *interconnected*.

Figure 6.6 represent the visualization of participant BO3, one of the middle school teachers. The participant' purpose was to show that both disciplines are separated but connected to each other. It can be concluded that the model falls in the category of interconnected.

6.1.1.2. The Analysis of the Research Question 1b. The research question 1b is "How do STEM education researchers and middle school teachers who get the average score on the TSESSP, conceptualize STEM education?". The research question aimed to investigate the STEM education researchers' and middle school science, mathematics and information technologies teachers' STEM education conceptions. The participants in this group got scores around the mean on TSESSP. STEM education conception is examined under 6 main themes that includes Definition of STEM Education, Goals of STEM education, Outcomes of STEM education, Nature and scope of integration in STEM education, Implementation of STEM education and Visualizations of STEM education.

(i) **The Definition of STEM Education.** For the first theme, the interviews of STEM education researchers and middle school teachers who got average score on TSESSP examined one by one. The first question in SECLDIP aimed to collect answers for the definition of STEM education. It was seen that the participants touched on different and similar points in the categories determined below in each group. The Figure 6.6 shows the categories determined by deductive coding, subcategories by inductive coding and codes emerged for *the definition* of STEM education for the groups of STEM education researchers and middle school teachers who got a score around the mean.

Table 6.6. Categories, subcategories and codes emerged for the *definition of STEM education* for the groups who got a score around the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Instructional aspect	Improve 21st century skills • Creativity • Critical thinking skills • Knowledge Including multiple tasks Real life problem solving	Improve 21st century skills • Creativity • Innovative thinking • Analytical thinking Produce something new Product making Reinforce the learned topics
Interdisciplinary nature of STEM education	Integration of disciplines Integration of social sciences Integration of art	Integration of technology in lessons Integration of disciplines
Theoretical aspect	Educational paradigm Educational program Educational approach Roof concept Philosophical perspective • Progressivist perspective	

The answers of the first interview question were coded under the theme of *definition* including 3 categories of *instructional* aspect, *interdisciplinary nature of STEM education* and *theoretical* aspects determined by inductive coding. Although, STEM education researchers and middle school teachers had similar points (e.g. improving 21st century skills), they also had different perspectives under the category of *instructional aspect*. STEM education researchers had perspectives that STEM education is a learning process with including real-life problem solving while middle school teachers explained that STEM education is product making to reinforce the learned objectives of a lesson.

From the *interdisciplinary nature of STEM education* aspect, two groups have one similar point that STEM education was any integration of more than one discipline. However, STEM education researchers also believe that social sciences and art could be integrated in STEM education while middle school teachers define that STEM education was integration of disciplines. For the *theoretical aspect*, STEM education researchers provided many explanations such as educational paradigm, an educational program, an educational approach, a roof concept, philosophical perspective and progressivist perspective while middle school teachers did not provide any definition of STEM education from the theoretical aspect.

If the frequencies of STEM education researchers' data examined, it is observed that the codes of *integration of disciplines* (f=3) and *real-life problem solving* (f=3) emerged most frequently for the theme of *definition*. When the frequencies of middle school teachers' data examined, it is observed that the code of *product making* (f=2) emerged most frequently for the theme of *definition*.

(ii) **The Goals of STEM Education.** For the second theme, the interviews of STEM education researchers and middle school teachers who got a score around the mean, examined one by one. The second question in SECLDIP aimed to collect answers for the goals of STEM education. The goals theme has 2 main categories identified before the interview analysis. The categories included goals for students and goals for teachers. Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score around the mean. The Table 6.7 shows the categories determined by deductive coding, subcategories by inductive coding and codes emerged for *goals* of STEM education for the groups of STEM education researchers and middle school teachers who got a score around the mean.

Table 6.7. Categories, subcategories and codes emerged for the *goals of STEM education* for the groups who got a score around the mean.

Categories	Subcategories and Codes of STEM education researchers	Subcategories and Codes of middle school teachers
Regarding Students	Improve 21st century skills • Problem solving skills • Critical thinking skills • Entrepreneurship skills • Social skills • Conflict resolution skills • Transformative competencies Raising competent individuals STEM workforce readiness STEM literacy Gaining holistic perspective	Improve 21st century skills • Improving creativity Increase motivation Being aware of real-life implementation of disciplinary concepts
Regarding Teachers	Cooperation among field teachers Gaining knowledge of other disciplines Gaining engineering literacy Increase job satisfaction	Raising awareness for real life problem solving Improving pedagogical content knowledge Gaining knowledge of other disciplines

The answers of the second interview question were coded under the theme of *goals* including 2 categories of *students* and *teacher* aspects. The STEM education researchers explained the goals of STEM education as improving 21st century skills, improving transformative competencies, raising competent individuals, STEM workforce readiness, STEM literacy and gaining holistic perspective while middle school teachers only defined the goals of STEM education as creating genuine products, improving creativity, gaining different experience, increase motivation and being aware of real-life implementation of disciplinary concepts. It was evaluated that the middle school teachers focused on that STEM education is product making which increase the real-life implementation of disciplinary concepts. However, STEM education researchers explained the goals of STEM education from variety of angles.

For the category of teacher aspects, STEM education researchers stated that STEM education aims to increase the collaboration between field teachers with providing gaining knowledge of other disciplines, gain engineering literacy and increase job satisfaction. The middle school teachers stated that STEM education aims to develop different perspectives for real life problems, improving pedagogical content knowledge and gaining knowledge of other disciplines. The teachers provided answers based on their own experiences underlining specific beneficial points while STEM education researchers provided more general aspects including different aspects for both categories.

If the frequencies of STEM education researchers' data examined, it is observed that the codes of *improving 21st century skills* (f=3), *raising competent individuals* (f=2) and *STEM workforce readiness* (f=2) emerged most frequently for the theme of goals of *students*. When the frequencies of middle school teachers' data examined, it is observed that the code of *being aware of real-life implementation of disciplinary concepts* (f=3) emerged most frequently for the theme of *goals of students*.

If the frequencies of STEM education researchers' data examined, it is observed that the codes of *gaining knowledge of other disciplines* (f=2) emerged most frequently for the theme of *goals of teachers*. When the frequencies of middle school teachers' data examined, it is observed that each code that was emerged has the same frequency (f=1) for the theme of *goals of teachers*.

(iii) **The Outcomes of STEM Education.** For the third theme, the interviews of STEM education researchers and middle school teachers who got a score around the mean, examined one by one. The third and the fourth question in SECLDIP aimed to collect answers for the outcomes of STEM education. The outcomes theme had 2 main categories identified before the interview analysis. The categories included outcomes for students and goals for teachers. Each category was discussed in more detail with giving specific examples from the responses of

STEM education researchers and middle school teachers who got a score around the mean. Table 6.8. shows the categories determined by deductive coding, subcategories by inductive coding and codes emerged for *the outcomes* of STEM education for the groups of STEM education researchers and middle school teachers who got a score around the mean.

Table 6.8. Categories, subcategories and codes emerged for the *outcomes of STEM education* for the groups who got a score around the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Regarding Students	Skill Outcomes • Self-management skills • Collaboration skills • Project design skills Cognitive Outcomes • Gaining holistic perspective • STEM literacy • Being aware of real-life implementation of disciplinary concepts • STEM workforce readiness Affective Outcomes • Increase motivation	Skill Outcomes • Self-management skills • Improve analytical thinking skills Cognitive Outcomes • Gaining holistic perspective • Improving imagination Affective Outcomes • Gaining positive attitude • Increase motivation Psychomotor Outcomes • Psychomotor skills
Regarding Teachers	Cognitive Outcomes • Being aware of real-life implementation of disciplinary concepts Pedagogical content knowledge Practical implications • Cooperation among field teachers • Problem based teaching • Project based teaching • Student centered lessons Affective Outcomes • Increase in motivation towards teaching	Cognitive Outcomes • Gaining knowledge of other disciplines Pedagogical content knowledge Practical implications • Activity based teaching • Process oriented assessment Skills Outcomes • Improving transformative competencies

The answers of the third and fourth interview questions were coded under the theme of *outcomes* including 2 categories of *students* and *teacher* aspects.

For the first category of *student* aspects, STEM education researchers and middle school teachers had similar points under the subcategories of skill outcomes, cognitive outcomes and affective outcomes while differ in psychomotor outcomes. Middle school teachers also mentioned that *psychomotor* outcomes of students develop during the process of STEM integrated lessons, but STEM education researchers did not mention anything that can fall under *psychomotor* outcomes. However, STEM education researchers provided more extensive answers for *skill* outcomes, cognitive outcomes and *affective* outcomes.

For the second category of teacher aspects, STEM education researchers and middle school teachers had some points in common under the subcategories of *cognitive outcomes, increase in pedagogical content knowledge and practical implications*. Even if there were commonalities under *practical implications* category, STEM education researchers provided variety of views such as cooperation among field teachers, problem-based teaching, project-based teaching and student-centered lessons while middle school teachers only provided answers as activity-based teaching and process-oriented assessment. In addition, STEM education researchers also stated answers that was categorized under *affective* and *skills* outcomes as a subcategory. It is stated that teachers also improve transformative competencies and increase motivation towards teaching.

If the frequencies of STEM education researchers' data examined, it is observed that the subcategory of *skill outcomes* (f=5) emerged most frequently for the theme of *goals of students*. When the frequencies of middle school teachers' data examined, it is observed that the subcategory of *cognitive outcomes* (f=4) emerged most frequently for the theme of *goals of students*.

If the frequencies of STEM education researchers' data examined, it is observed that the code of *improving pedagogical content knowledge* (f=2) emerged most frequently for the theme of *goals of teachers*. When the frequencies of middle school teachers' data examined, it is observed that each code that was emerged has the same frequency (f=1) for the theme of *goals of teachers.*

(iv) **The Nature and Scope of Integration in STEM Education.** For the fourth theme, the interviews of STEM education researchers and middle school teachers who got a score around the mean, examined one by one. The fifth and the sixth questions in SECLDIP aimed to collect answers for the nature and scope of STEM education. *The nature and scope of integration* theme had 2 main categories identified before the interview analysis. The categories include *the relation between disciplines and duration, size and complexity of practice.* Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score around the mean. Table 6.9 shows the categories determined by deductive coding, subcategories determined by inductive coding and codes emerged for *the nature and scope of integration* of STEM education for the groups of STEM education researchers and middle school teachers who got a score around the mean.

Table 6.9. Categories, subcategories and codes emerged for the *nature and scope of integration of STEM education* for the groups who got a score around the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Type of STEM connections	Naturel connection of disciplines in a real-life problem	Connection of concepts from disciplines
Planning of STEM activities	Complexity • Depends on the type of question • Depends on the project • Depends on the readiness level of the students • Depends on the grade level • Simplified Duration and Size • Depends on the type of question • Depends on the project • Depends on the content • Depends on the deepening	Complexity • Depends on the readiness level of the students • Depends on the content • Depends on the grade level • Simplified Duration and Size • Hour-based • Week-based

The answers of the fifth and sixth interview questions were coded under the theme of *the nature and scope of integration* including 2 categories of *relation between disciplines* and *duration, size and complexity of STEM activity.* For the *relation between disciplines* category, STEM education researchers stated that STEM education is naturel connection of disciplines in a real-life problem while middle school teachers explained that STEM education is connection of concepts from disciplines. It is obvious that middle school teachers view STEM education as a tool to connect disciplinary concepts rather than a real-life problem solving with the integration of disciplines.

For the *duration, planning on STEM activities* category, two subcategories were identified as *complexity and duration and size.* STEM education researchers and middle school teachers had commonalities under *complexity* subcategory such that the activity for STEM education depends on the grade level, readiness level of the students and it should be simplified since students get confused during the process. For the *duration and size*, middle school teachers provided certain durations for STEM education such as hour-based and week-based while STEM education researchers avoided to give certain time limits for application with stating that it depends on the question, the project, the content and the deepening of the context.

If the frequencies of STEM education researchers' data examined, it is observed that the code of *naturel connection of disciplines in a real-life problem* (f=3) emerged most frequently for the subcategory of *types of STEM connection.* When the frequencies of middle school teachers' data examined, it is observed that the code of *connection of concepts from disciplines* (f=3) emerged most frequently for the subcategory of *types of STEM connection.*

If the frequencies of STEM education researchers' data examined, it is observed that the code of *depends on the deepening* (f=2) emerged most frequently for the subcategory of complexity of STEM activities and depends on the question (f=2) emerged most frequently for the subcategory of *duration and size of STEM activities.* When the frequencies of middle school teachers' it is observed that the code of *depends on the content* (f=2) emerged most frequently for the subcategory of *complexity of STEM activities and week-based* (f=2) emerged most frequently for the subcategory of *duration and size of STEM activities.*

(v) **The Implementation of STEM Education.** For the fifth theme, the interviews of STEM education researchers and middle school teachers who got a score around the mean, examined one by one. The seventh and eighth questions in SECLDIP aimed to collect answers for implementation of STEM education. *The implementation of STEM education* theme had 2 main categories identified before the interview analysis. The categories include *instructional design* and *integration in class.* Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score around the mean. Table 6.10. shows the categories determined by deductive coding and codes emerged for *the implementation of STEM education* for the groups of STEM education researchers and middle school teachers who got a score around the mean.

Table 6.10. Categories and codes emerged for the *implementation of STEM education* for the groups who got a score around the mean.

Categories	**Codes of STEM education researchers**	**Codes of middle school teachers**
Instructional Design	Instructional analysis Deciding on learning objectives Deciding on the assessment Deciding on teaching techniques and methods Depends on the need analysis Deciding on practice Literature analysis Getting disciplinary expert's opinions Development of the instructional design Implementation of instructional design Evaluation of the instructional design	Deciding on learning objectives Deciding on materials Deciding on the instructions Arrangements of groups Deciding on practice Development of the instructional design Implementation of instructional design Evaluation of the instructional design Evaluating the readiness level of students
Integration in b **Class**	Integration of disciplinary concepts and skills around disciplinary practices integration of disciplinary concepts and practices around a real-life problem	Integration of disciplinary concepts and practices around a product Group work

The answers of the seventh and eight interview questions were coded under the theme of *implementation* including 2 categories of *instructional design* and *integration in class.* For the first category of *instructional design*, there were some similarities between the groups at some points such as deciding on learning objectives, deciding on practice, development of the instructional design, implementation of instructional design and evaluation of the instructional design. However, STEM education researchers differed from middle school teachers at some points such that need analysis, deciding on the assessment, deciding on teaching techniques and methods, literature analysis and getting disciplinary expert's opinions were important for STEM education instructional designs. Middle school teachers also differed at some points such as deciding on materials, deciding on the given instructions for the activities and arrangements of groups.

For the *integration in class category*, there was a distinct difference between two groups. STEM education researchers indicated that STEM education can be integrated to the classroom setting as integrating disciplinary concepts and skills around disciplinary practices such as engineering practices and integrating disciplinary concepts and practices around a real-life problem. However, middle school teachers indicated that integration can be done by integrating disciplinary concepts and practices around a product with group works.

If the frequencies of STEM education researchers' data examined, it is observed that the codes of *depends on the need analysis* (f=2) and *deciding on learning objectives* (f=2) emerged most frequently for the category of *instructional design.* When the frequencies of middle school teachers' data examined, it is observed that the code of *deciding on learning objectives* (f=2) emerged most frequently for the category of *instructional design.*

If the frequencies of STEM education researchers' data examined, it is observed that the codes of *integration of disciplinary concepts and skills around disciplinary practices* (f=2) and *deciding on learning objectives* (f=2) emerged most frequently for the category of *integration in class.* When the frequencies of middle school teachers' data examined, it is observed that the code of *integration of disciplinary concepts and practices around a product* (f=2) emerged most frequently for the category of *integration in class.*

(vi) **The Visualizations of STEM Education.** For the sixth theme, the visualizations of STEM education researchers and middle school teachers who got a score around the mean, examined one by one. The ninth questions in SECLDIP aimed to collect answers from the participants about how they visualize STEM education. The *visualization* theme was categorized based on by Bybee (2013). The visualizations informed the researcher about the mental images of STEM education in participants cognitive understanding.

The visualizations of Bybee (2013) were evaluated under 6 main categories as it is used in the literature (Radloff and Guzey, 2016; Ogan-Bekiroğlu and Caner, 2018). The names of the categories are nested, transdisciplinary, interconnected, sequential, overlapping, and siloed. There were 2 categories emerged for STEM education researchers including *transdisciplinary* (N=2) and *interconnected* (N=1). There were 3 categories emerged for middle school teachers group including *interconnected, nested and siloed.*

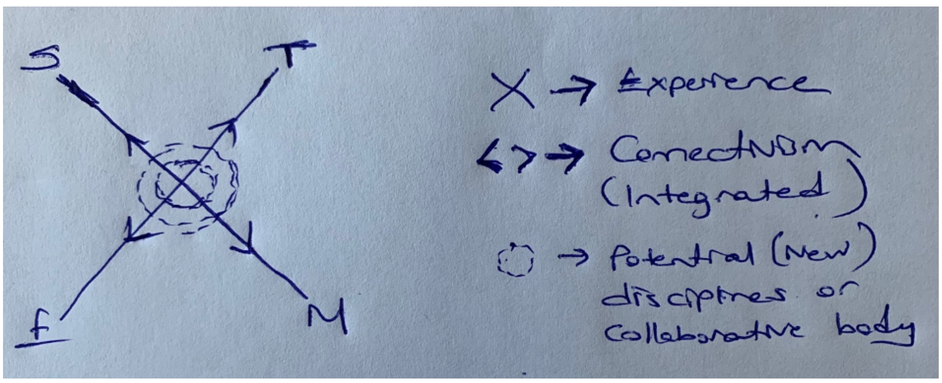


Figure 6.7. Visualization of A7 coded as *transdisciplinary.*

The Figure 6.7 represent the visualization of participant A7, one of the STEM education researchers. The participant put the X at the center of the model which is related to real life experience. The arrows show the integrated nature of the STEM education. The circles in the middle indicates the other potential disciplines or collaborative bodies including entrepreneurship, innovation, art, music. It can be concluded that the model falls in the *transdisciplinary* category.

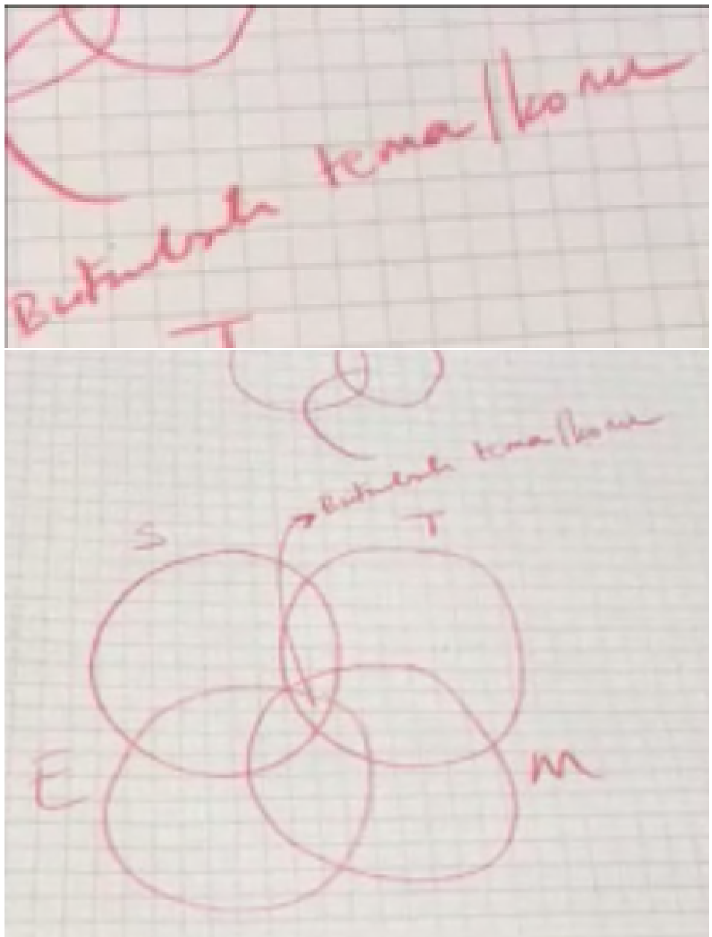


Figure 6.8. Visualization of A14 coded as *interconnected*.

The Figure 6.8 represent the visualization of participant A14, one of the STEM education researchers. The participant wrote "integrated theme or topic" in the middle of the Venn diagram. There are points where each discipline here intersects as a duo or trio. It can be concluded that the model falls in the *interconnected* category which indicates that boundaries across disciplines are separated by coordinated concepts, procedures, and resources (Bybee, 2013).

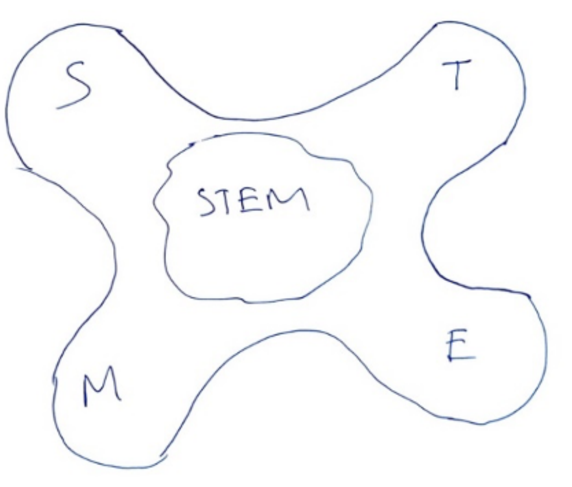


Figure 6.9. Visualization of A24 coded as *transdisciplinary*.

The Figure 6.9 represent the visualization of participant A24, one of the STEM education researchers. The participant associated STEM education with marbling art. The integration of the disciplines could be achieved with real life problems. It can be concluded that the model falls in the *transdisciplinary* category which indicates that to focus on the real-world application or problems (Bybee, 2013).

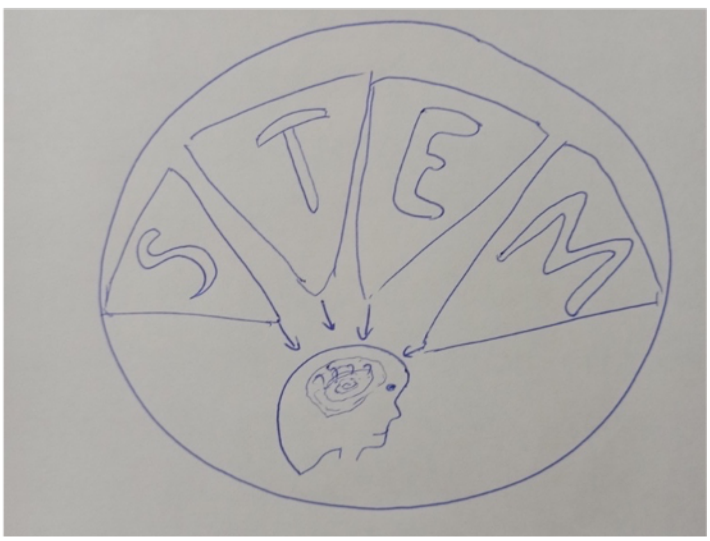


Figure 6.10. Visualization of FO4 coded as *interconnected*.

The Figure 6.10 represent the visualization of participant FO4, one of the middle school teachers. The participant associates STEM education with making products by combining disciplinary subjects. The integration of the disciplines can be achieved with integrating disciplinary concepts by a process. It can be concluded that the model falls in the *interconnected* category which indicates that boundaries across disciplines are separated by coordinated concepts, procedures, and resources (Bybee, 2013).

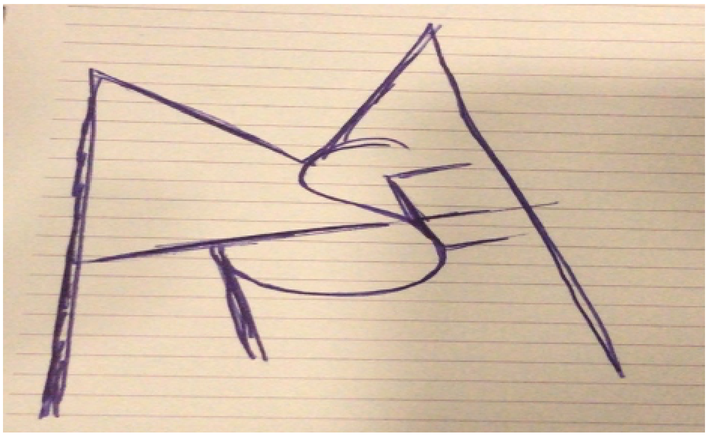


Figure 6.11. Visualization of MO3 coded as *nested*.

The Figure 6.11 represent the visualization of participant MO3, one of the middle school teachers. The participant' purpose was to show that mathematics is the essential component in science, mathematics and technology. It can be concluded that the model falls in the category of nested. All the disciplines including science, technology and engineering are connected by mathematics.

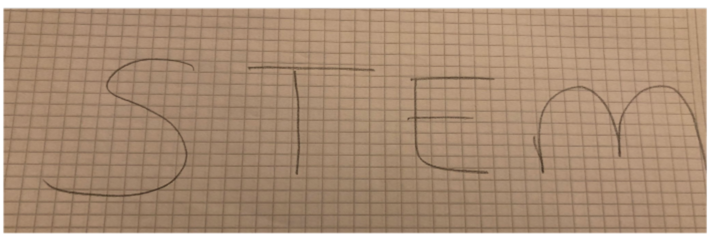


Figure 6.12. Visualization of BO10 coded as *siloed*.

The Figure 6.12 represent the visualization of participant BO10, one of the middle school teachers. The participant' purpose was to show that both disciplines are separated as a discipline. It can be concluded that the model falls in the category of *siloed*.

6.1.1.3. The Analysis of the Research Question 1c. The research question 1c is "How do STEM education researchers and middle school teachers who get the score that is at least one standard deviation lower than the average score on the TSESSP, conceptualize STEM education?". The research question aims to investigate the STEM education researchers' and middle school science, mathematics and information technologies teachers' STEM education conceptions. The participants in this group got scores one SD lower than the mean on TSESSP. STEM education conception is examined under 6 main themes that includes Definition of STEM Education, Goals of STEM education, Outcomes of STEM education, Nature and scope of integration in STEM education, Implementation of STEM education and Visualizations of STEM education.

(i) **The Definition of STEM Education.** For the first theme, the interviews of STEM education researchers and middle school teachers who got a score one SD lower than the mean on TSESSP examined one by one. The first question in SECLDIP aimed to collect answers for the definition of STEM education. It was seen that the participants touched on different and similar points in the categories determined below in each group. The Table 6.11 shows the categories determined by inductive coding and codes emerged for *definition* of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD lower than the mean.

Table 6.11. Categories and codes emerged for the *definition of STEM education* for the groups who got a score one SD lower than the mean.

Categories	**Codes of STEM education researchers**	**Codes of middle school teachers**
Instructional aspect	Improve 21st century skills • Knowledge Product making Real life problem solving	Improve 21st century skills • Project design skills Product making Real life problem solving Reinforce the learned topics Raising competent individuals
Interdisciplinary nature of STEM education	Integration of disciplines Integration of art	Integration of disciplines Integration of art
Theoretical aspect	Educational approach	Educational program

The answers of the first interview question were coded under the theme of *definition* including 3 categories of *instructional* aspect, *interdisciplinary nature of STEM education* and *theoretical* aspects. Although there were some similarities between the two groups for *instructional* aspect (e.g. real life problem solving), two groups differed from each other in some points. Middle school teachers provided answers that STEM education is learning by doing to improve project design skills and raise competent individuals while STEM education teachers stated that it is a learning process by product making and reflection of real life in education setting.

For the *interdisciplinary nature of STEM education* category, common codes appeared between two groups as integration of disciplines and integration of art. However, middle school teachers also stated that STEM education is integration of disciplinary perspectives. For the *theoretical* aspect, STEM education researchers stated that STEM education is educational approach while middle school teachers explained that STEM education is educational program.

For the *definition* theme, middle school teachers provided additional codes including STEM education is integration of disciplinary perspectives and provides raising competent individuals for future.

If the frequencies of STEM education researchers' data examined, it is observed that the codes of *integration of disciplines* (f=2) and *product making* (f=2) emerged most frequently for the theme of *definition*. When the frequencies of middle school teachers' data examined, it is observed that each code emerged the same frequency (f=1) for the theme of *definition*.

(ii) **The Goals of STEM Education.** For the second theme, the interviews of STEM education researchers and middle school teachers who got a score one SD lower than the mean, examined one by one. The second question in SECLDIP aimed to collect answers for the goals of STEM education. The *goals of STEM education* theme had 2 main categories identified before the analysis of interview. The categories included goals for students and goals for teachers. Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score one SD lower than the mean. The Table 6.12 shows the categories determined by deductive coding and codes emerged for goals of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD lower than the mean.

Table 6.12. Categories and codes emerged for the *goals of STEM education* for the groups who got a score one SD lower than the mean.

Categories	Codes of STEM education researchers	Codes of middle school teachers
Regarding Students	Improving 21st century skills • Problem solving skills Being aware of real-life implementation of disciplinary concepts Permanent learning Raising awareness for real life problem solving Gaining holistic perspective	Improving 21st century skills • Project design skills, • Interdisciplinary thinking skills • Scientific thinking Being aware of real-life implementation of disciplinary concepts
Regarding Teachers	Improving 21st century skills Improving creativity Raising awareness for real life problem solving Cooperation among field teachers Collaboration with experts	Cooperation among field teachers Improving creativity Developing perspective Gaining knowledge of other disciplines

The answers of the second interview question were coded under the theme of *goals* including 2 categories of *student and teacher aspects*. For the *student* aspect, there were common codes appeared including improving 21st century skills and being aware of real-life implementation of disciplinary concepts. However, STEM education researchers provided more codes under student category such as permanent learning, raising awareness for real life problem solving, improving problem solving skills, gaining holistic perspective. Although there were similar codes under *teacher* category for both groups (e.g. Cooperation among field teachers and improving creativity), STEM education researchers also included that STEM education aims collaboration with experts from different professions, integration of disciplinary perspectives and improving 21st century skills. Middle school teachers also stated that STEM education aim to gain knowledge of other disciplines.

If the frequencies of STEM education researchers' data examined, it is observed that the code of *being aware of real-life implementation of disciplinary* *concepts* (f=2) emerged most frequently for the theme of *student goals*. When the frequencies of middle school teachers' data examined, it is observed the code of *being aware of real-life implementation of disciplinary concepts* (f=2) emerged most frequently for the theme of student goals.

If the frequencies of STEM education researchers" data examined, it is observed that the codes of *cooperation among field teachers* (f=2) and *raising awareness for real life problem solving* (f=2) emerged most frequently for the theme of *teacher goals*. When the frequencies of middle school teachers' data examined, it is observed the code of *gaining knowledge of other disciplines* (f=2) emerged most frequently for the theme of *teacher goals*.

(iii) **The Outcomes of STEM Education.** For the third theme, the interviews of STEM education researchers and middle school teachers who got a score one SD lower than the mean, examined one by one. The third and the fourth question in SECLDIP aimed to collect answers for the goals of STEM education. The *outcomes* theme has 2 main categories identified before the analysis of interviews. The categories include outcomes for students and outcomes for teachers. Each category will be discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score one SD lower than the mean.Table 6.13 shows the categories determined by deductive coding, subcategories by inductive coding and codes emerged for *outcomes* of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD lower than the mean.

Table 6.13. Categories, subcategories and codes emerged for the *outcomes of STEM education* for the groups who got a score one SD lower than the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Regarding Students	Skill Outcomes • Real life problem solving with project • Collaboration skills • Self-management skills • Communication skill • 21st century skills • Creativity Cognitive Outcomes • Increase academic achievement • Gaining holistic perspective Affective Outcomes • Increase motivation • Gaining positive attitude Psychomotor Outcomes	Skill Outcomes • Communication skills • Improve problem solving skills Cognitive Outcomes • Being aware of real-life implementation of disciplinary concepts • Gaining holistic perspective Affective Outcomes • Increase in self confidence • Increase motivation • Gaining positive attitude
Regarding Teachers	Cognitive Outcomes • Gaining knowledge of other disciplines Pedagogical content knowledge Practical implications • Group works • Project based teaching • Problem based teaching • Student centered lessons • Cooperation among field teachers Affective Outcomes • Increase motivation • Increase in self confidence	Cognitive Outcomes • Gaining knowledge of other disciplines Pedagogical content knowledge Practical implications • Group works • Questioning • Cooperation among field teachers • Student centered lessons • Integration of disciplines

The answers of the third and fourth interview questions were coded under the theme of *outcomes* including 2 categories of *students* and *teacher* aspects.

For the first category of *student* aspects, there were similar subcategories determined for both groups including *skill* outcomes, cognitive outcomes and *affective* outcomes. However, STEM education researchers differed from middle school teachers at some points such as psychomotor outcomes. STEM education researchers also provided more insight about the *skill* outcomes including *collaboration skills* and *self-management skills.* For the *teacher* aspects, STEM education researchers and middle school teachers had same subcategories appeared during the coding such as *skill outcomes*, *cognitive outcomes, improving pedagogical content knowledge* and *practical implications.* However, STEM education researchers also provided outcomes based on *affective outcomes* for teachers including increase motivation and increase in self-confidence.

If the frequencies of STEM education researchers' data examined, it is observed that the code of *increase motivation* (f=2) emerged most frequently for the theme of *outcomes of students.* When the frequencies of middle school teachers' data examined, it is observed that the codes of *increase in self-confidence* (f=2) and *improve communication skills* (f=2) emerged most frequently for the theme of *outcomes of students.*

If the frequencies of STEM education researchers' data examined, it is observed that the code of *problem-based teaching* (f=3) emerged most frequently for the theme of *outcomes of teachers.* When the frequencies of middle school teachers' data examined, it is observed that each *code of student-centered lessons* (f=2) emerged most frequently for the theme of *outcomes of teachers.*

(iv) **The Nature and Scope of Integration in STEM Education.** For the fourth theme, the interviews of STEM education researchers and middle school teachers who got a score one SD lower than the mean, examined one by one. The fifth and the sixth questions in SECLDIP aimed to collect answers for the nature and scope of STEM education. *The nature and scope of integration* theme has 2 main categories identified before the analysis of interview. The categories included *the* *relation between disciplines* and *duration, size and complexity of practice.* Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score one SD lower than the mean. Table 6.14 shows the categories determined by deductive coding, subcategories determined by inductive coding and codes emerged for the *nature and scope of integration* of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD lower than the mean.

Table 6.14. Categories, subcategories and codes emerged for *the nature and scope of integration of STEM education* for the groups who got a score one SD lower than the mean.

Categories	**Subcategories and Codes of STEM education researchers**	**Subcategories and Codes of middle school teachers**
Type of STEM connections	Connection of concepts from disciplines Naturel connection of disciplines in a real-life problem	Connection of concepts from disciplines Connection of concepts from disciplines to practice technology and engineering
Planning of STEM activities	Complexity • Depends on grade level • Challenging • Simplified • Depends on the readiness level of students • Depends on the learning outcome Duration and Size • Depends on the product • Depends on grade level • Depends on the readiness level of the students • Depends on the context	Complexity • Depends on the readiness level of the students • Detailed • Depends on the real-life problems Duration and Size • Depends on the project • week-based • Depends on grade level

The answers of the fifth and sixth interview questions were coded under the theme of the *nature and scope of integration* including 2 categories of *relation* *between disciplines* and *duration, size and complexity of STEM activities.* For the *relation between disciplines* category, participants provided variety of perspectives based on STEM education. STEM education researchers stated that the relation of disciplines was a connection of concepts from disciplines and naturel connection of disciplines in a real-life problem. On the other hand, middle school teachers provided answer that STEM is connection of concepts from disciplines similar to the researchers but one more code appeared in the answers including STEM is connection of concepts from disciplines to practice technology and engineering.

For the *duration, size and complexity of STEM activities* category, two subcategories were identified as *complexity and duration and size.* STEM education researchers and middle school teachers avoid giving exact answers for the *complexity* and *duration and size* of STEM education because it depends on variety of reasons such as depending on grade level, readiness level of students, learning outcome and the real-life problems. Some of the STEM education researchers agreed with STEM education teachers at the points that STEM education should not be too complex for students while one of the STEM education researchers explained that it could be challenging at some level which students can conduct.

If the frequencies of STEM education researchers' data examined, it is observed that the code of *connection of concepts from disciplines* (f=2) emerged most frequently for the subcategory of *types of STEM connection.* When the frequencies of middle school teachers' data examined, it is observed that the code of *connection of concepts from disciplines to practice technology and engineering* (f=2) emerged most frequently for the subcategory of *types of STEM connection.*

If the frequencies of STEM education researchers' data examined, it is observed that the codes emerged has the same frequency (f=1) for the subcategory of *complexity, duration and size of STEM activities.* When the frequencies of middle school teachers' it is observed that the code of *depends on the readiness level of students* (f=2) emerged most frequently for the subcategory of *complexity* *of STEM activities* and other codes had the same frequency (f=1) for the sub-category of *duration and size of STEM activities.*

(v) **The Implementation of STEM Education.** For the fifth theme, the interviews of STEM education researchers and middle school teachers who got a score one SD lower than the mean, examined one by one. The seventh and eighth questions in SECLDIP aimed to collect answers for implementation of STEM education. *The implementation of STEM education theme* has 2 main categories identified before the interview analysis. The categories included *instructional design and integration in class.* Each category was discussed in more detail with giving specific examples from the responses of STEM education researchers and middle school teachers who got a score one SD lower than the mean. Table 6.15 shows the categories determined by deductive coding and codes emerged for *implementation* of STEM education for the groups of STEM education researchers and middle school teachers who got a score one SD lower than the mean.

Table 6.15. Categories and codes emerged for the theme of *implementation of STEM education* for the groups who got a score one SD lower than the mean.

Categories	**Codes of STEM education researchers**	**Codes of middle school teachers**
Instructional Design	Deciding on learning objectives Lesson plan preparation Literature analysis Deciding on practice Deciding on materials Deciding on the assessment Evaluating the readiness level of students Deciding on teaching techniques and methods Need analysis • content analysis • target analysis • task analysis	Lesson plan preparation Duration of the lesson Deciding on practice Deciding on materials Brain storming
Integration in Class	integration of disciplinary concepts and practices around a product integration of disciplinary concepts and practices around a real-life problem Cooperation among field teachers Brain storming	integration of disciplinary concepts and practices around a product integration of disciplinary concepts and practices around a real-life problem

The answers of the seventh and eight interview questions were coded under the theme of *implementation* including 2 categories of instructional design and *integration in class*. For the first category of *instructional design*, although there were some similarities between the two groups (e.g. lesson plan preparation, deciding on materials and deciding on practice), STEM education researchers provided more answers from theoretical aspect such as literature analysis, deciding on the assessment, deciding on teaching techniques and methods, evaluating the readiness level of students, need analysis, content analysis, target analysis and task analysis to be done.

For the *integration in class* aspect, there were similar answers including integration of disciplinary concepts and practices around a product and integration of disciplinary concepts and practices around a real-life problem. STEM education researchers also included that Cooperation among field teachers is important for disciplines to be meaningfully integrated in the classroom setting.

If the frequencies of STEM education researchers' data examined, it is observed that the code of *deciding on the assessment* (f=3) and *deciding on the learning objectives* (f=2) emerged most frequently for the category of *instructional design.* When the frequencies of middle school teachers' data examined, it is observed that the code of *deciding on materials* (f=2) emerged most frequently for the category of *instructional design.*

If the frequencies of STEM education researchers' data examined, it is observed that the code of *integration of disciplinary concepts and practices around a real-life problem* (f=2) emerged most frequently for the category of integration in class. When the frequencies of middle school teachers' data examined, it is observed that the code of *integration of disciplinary concepts and practices around a product* (f=2) emerged most frequently for the category of *integration in class.*

(vi) **The Visualizations of STEM Education.** For the sixth theme, the visualizations of STEM education researchers and middle school teachers who got a score one SD lower than the mean, examined one by one. The ninth questions in SE-CLDIP aimed to collect answers from the participants about how they visualize STEM education. The *visualization* theme was categorized based on by Bybee (2013). The visualizations informed the researcher about the mental images of STEM education in participants cognitive understanding. The visualizations of Bybee (2013) were evaluated under 6 main categories as it is used in the literature (Radloff and Guzey, 2016; Ogan-Bekiroğlu and Caner, 2018). The names of the categories are nested, transdisciplinary, interconnected, sequential, overlapping, and siloed. There were 3 categories emerged for *visualizations* theme including *transdisciplinary, sequential and interconnected* for STEM education researchers. There were 3 categories emerged as *siloed, interconnected* and *sequential* for middle school teachers.

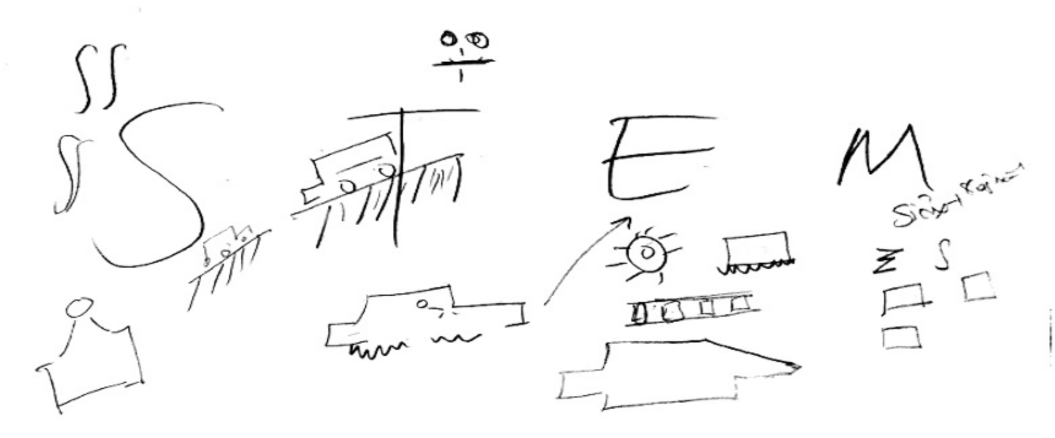


Figure 6.13. Visualization of A9 coded as *transdisciplinary.*

Figure 6.13 Visualization of A9 coded as transdisciplinary The Figure 6.13 represent the visualization of participant A7, one of the STEM education researchers. The participant drew a storyline which is related to real life experience. The vehicle which visits all the disciplines to show the integrated nature of the STEM education. The vehicle was explained as snow mobile that can be designed to solve a real-life problem with integrating all the STEM components. It can be concluded that the model falls in the *transdisciplinary* category.

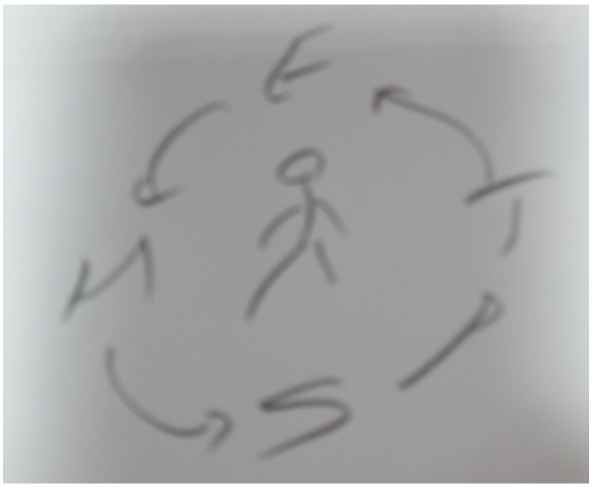


Figure 6.14. Visualization of A22 coded as *sequential*.

Figure 6.14 represent the visualization of participant A22, one of the STEM education researchers. The participant explained that all of the fields actually feed off each other. It is stated that it is not possible for any of them to be at the forefront, if there was no mathematics, there would be no technology. Without physics, without engineering, there would be no others. In this respect, none of them stand out. These fully support each other, progress and grow together, and the center of the event is human. It can be concluded that the model falls in the *sequential* category.

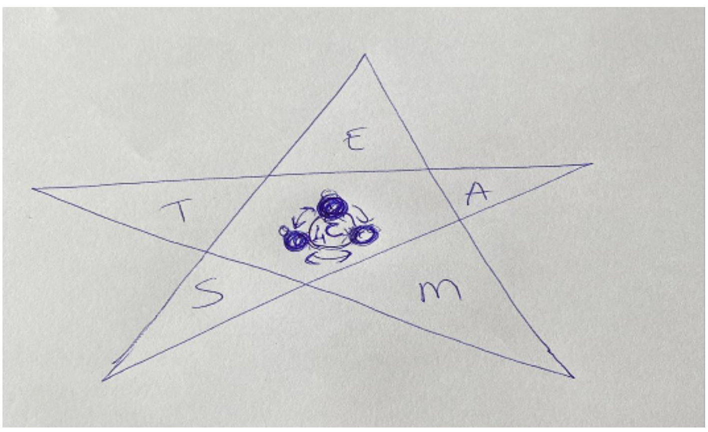


Figure 6.15. Visualization of A25 coded as *interconnected*.

The Figure 6.15 represent the visualization of participant A22, one of the STEM education researchers. The participant explained that if one of the disciplines is missing in the star, the process is completely destroyed. None of the disciplines at the center, they are equally distributed across the star. In the center, there is the teacher, the students, the teaching process. It can be concluded that the model falls in the *interconnected* category which indicates that boundaries across disciplines are separated by coordinated concepts, procedures, and resources (Bybee, 2013).

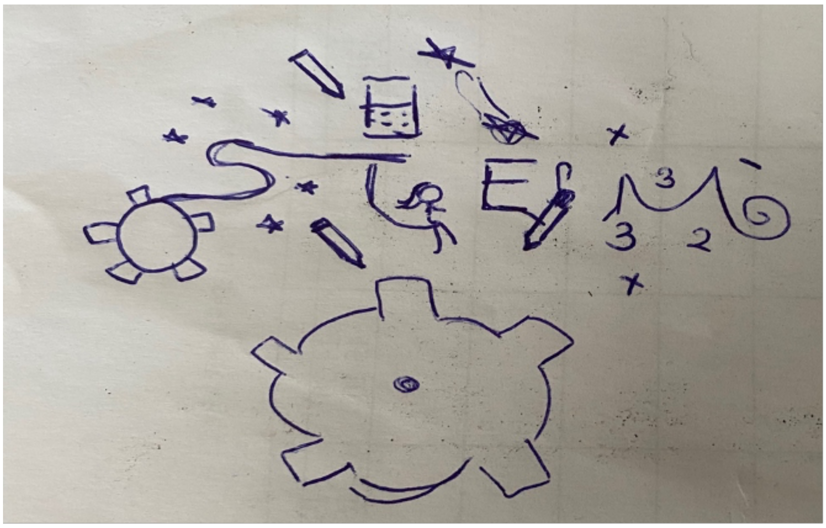


Figure 6.16. Visualization of FO3 coded as *siloed*.

The Figure 6.16 represent the visualization of participant FO3, one of the middle school teachers. The participant' purpose was to show that both disciplines are separated as a discipline. The researcher tried to understand if the connection between the letter S an T were intentional. However, the participant did not explain the relation of these two letters if it was symbolized by the line connected to both disciplines. It can be concluded that the model falls in the *siloed* category.

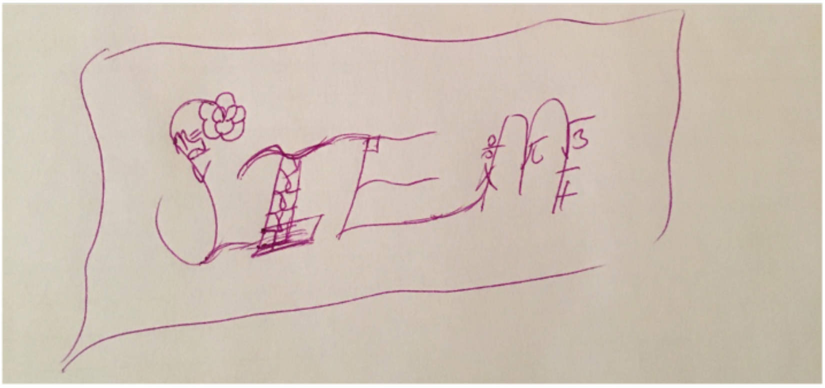


Figure 6.17. Visualization of MO1 coded as *interconnected*.

The Figure 6.17 represent the visualization of participant FO3, one of the middle school teachers. The participant' purpose was to show that STEM is an interdisciplinary transition. The disciplined are combined. It can be concluded that the model falls in the interconnected category.

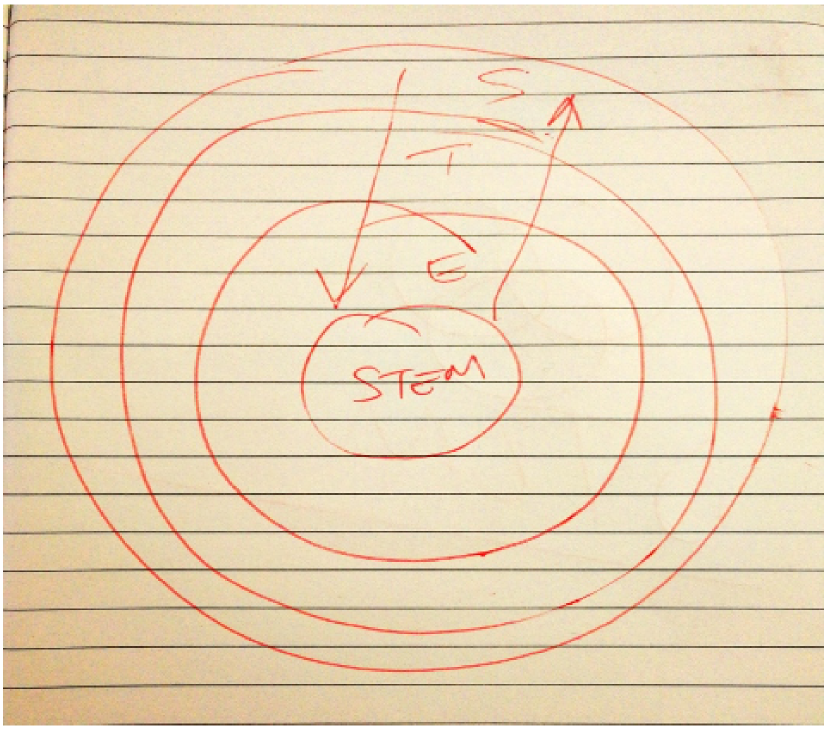


Figure 6.18. Visualization of BO9 coded as *sequential*.

The Figure 6.18 represent the visualization of participant FO3, one of the middle school teachers. The participant explained that the order of the letter from the inside to out changes. Sometimes, based on the lesson, technology can be most inclusive, or mathematics. Although the order here actually changes, there is actually STEM in the middle. Based on what the participant said, there is mathematics in science, there is technology in science, there is engineering in science, there is science in mathematics, there is technology and there is engineering. It can be concluded that the model falls in the *sequential* category.

6.1.2. Data Analysis for Other Questions of the Study

For the research question 1, the codes that were emerged most frequently for each theme explained briefly in this section based on the inductive and deductive thematic analysis. For the theme of *definition*, the codes that emerged most frequently were *real-life problem solving* (f=7) and *integration of disciplines* (f=6) for STEM education researchers. On the other hand, the codes emerged most frequently were *integration of disciplines* (f=4), *reinforce the learned topics* (f=3) and *product making* (f=3) for the middle school teachers.

For the theme of *goals*, there were two categories that was defined as *goals for students and goals for teachers.* The answers of the STEM education researchers revealed that the most frequently indicated codes were *improving 21st century skills* (f=7) and *raising competent individuals* (f=3) while middle school teachers most frequently indicated the code of *being aware of real-life implementation of disciplinary concepts* (f=7). STEM education researchers explained that *raising awareness in each disciplinary perspective for real life problem solving* (f=4) and *cooperation among field teachers* (f=4) were the *goals for teachers.* Middle school teachers explained that *gaining knowledge of other disciplines* (f=3) were the *goals for teachers.*

The theme *outcomes* included two categories as *outcomes for students and outcomes for teachers.* For the category of outcomes for students, STEM education researchers indicated most frequently the codes of *increase motivation* (f=4), *gaining holistic perspectives towards disciplines* (f=3) and *self-management skills* (f=3). On the other hand, middle school teachers indicated most frequently the codes of *gaining holistic perspectives towards disciplines* (f=3) and *improve communication skills* (f=3). For the category of *outcomes for teachers*, STEM education researchers explained that improving *pedagogical content knowledge* (f=5), *cooperation among field teachers* (f=4) and *problem-based teaching* (f=4) as codes. Middle school teachers explained that *active learning process* (f=3), *gaining knowledge of other disciplines* (f=2), *cooperation among field teachers* (f=2) and *improving pedagogical content knowledge* (f=2) as codes.

For the theme of *nature and scope of integration*, there were 2 categories namely *type of STEM connections and duration, size and complexity of practice.* STEM education researchers mostly explained STEM education as a code of *natural connection of disciplines in a real life-problem* (f=4) for the category of namely *type of STEM connections.* However, middle school teachers indicated that *connection of concepts from disciplines* (f=7) as a code for the category of namely *type of STEM connections.* Under the category of *duration, size and complexity of practice*, STEM education researchers expressed codes as *depends on the grade level* (f=5), *depends on the context* (f=4) and *depends on the readiness level of students* (f=3) with avoiding giving rigid answers for the duration and size of practice. Middle school teachers explained codes as *depends on the grade level* (f=3) and *depends on the readiness level of students* (f=3) for the complexity of a practice yet, they indicated that 1 class hour is not enough for conducting STEM activities. Therefore, they gave certain durations for the practices to be conducted such as *week-based* (f=3) and *hour-based* (f=1).

For the theme of *implementation*, there were two categories determined such as *instructional design and integration in class.* For the category of *instructional design*, almost all STEM education researchers explained the process of designing an instruction such as *deciding on learning objectives* (f=6), *deciding on assessment* (f=4), *deciding on practice* (f=4), *depends on need analysis* (f=3), *lesson plan preparation* (f=3) and *deciding on teaching techniques and methods* (f=3). On the other hand, middle school teachers expressed *deciding on materials* (f=4), *arrangement of the groups* (f=3) and *deciding on practice* (f=3) as codes. For the last category of *integration in class*, codes of *integration of disciplinary concepts and practices around a real-life problem* (f=4) and *integration of disciplinary concepts and skills around disciplinary practices* (f=2) emerged most frequently when the data of STEM education researchers examined. On the other hand, the code of *integration of disciplinary concepts and practices around a product* (f=7) mostly emerged for middle school teachers.

Apart from the textual data, the visualizations of STEM education models differ across the groups. There were wide range of STEM conceptions identified in the literature. However, the majority of them could be explained using Bybee's (2013) theoretical visualizations and were backed up by textual replies. For STEM education researchers, the identified visualizations fall under 5 categories; 3 *transdisciplinary*, 2 *interconnected*, 2 *nested*, 1 *sequential* and 1 *overlapping*. On the other hand, middle school teachers' visualizations under categories of 4 *interconnected*, 3 *siloed*, 1 *nested* and 1 *sequential*.

The qualitative data within groups were also evaluated in order to answer the second and third research question about the differences and similarities between the groups that have different levels of self-efficacy belief of STEM education. First of all, the middle school teachers who had scores one SD higher than the mean, around the mean and one SD lower than the mean on TSESSP were evaluated. Middle school teachers who had scores one SD higher than the mean on TSESSP were able to give comprehensive answers for the goals of students and for the goals of teachers. Middle school teachers who had scores around the mean on TSESSP identified outcomes of students in more comprehensive way. Middle school teachers who had scores one SD lower than the mean on TSESSP defined STEM education from broader aspects.

The STEM education researchers were also evaluated based on their conceptions within their participant group. It was identified that STEM education researchers who had scores one SD higher than the mean on TSESSP were able to give more comprehensive answers for the implementation of interdisciplinary nature of STEM education. Their answers were not only broad from the theoretical aspect but also in the implementation aspect of the STEM education in the classroom setting. However, it was deduced that STEM education researchers who had scores around the mean on TSESSP, provided wide variety of answers for the definition of STEM education especially under the category of theoretical aspect and goals for students. In addition, STEM education researchers who had scores one SD lower than the mean on TSESSP stated variety of perspectives in outcomes of students.

7. DISCUSSION AND CONCLUSION

This study aimed to investigate STEM education researchers' and middle school teachers' conception of STEM education based on their self-efficacy beliefs of STEM education. The explanatory sequential qualitative method was used as research design. The participants of this study consisted of 9 STEM education researchers and 9 middle school teachers including 3 science teacher, 3 mathematics teacher and 3 information technologies teacher. STEM education researchers and middle school teachers were selected by purposive sampling. The identified criteria for STEM education researchers were to be employed at a university in Turkey, to have conducted research study and published at least peer-reviewed journal article, book chapter or a thesis in the field of STEM education. The identified criteria for middle school teachers were to implement or practice STEM education in their classes. The participants were also selected based on their levels of self-efficacy beliefs which was assessed by Teacher Self-Efficacy Scale for STEM Practices (TSESSP).

The analysis of the data that was obtained in the study consist of 2 main parts namely, data analysis for self-efficacy belief levels of target population in order to select participants purposefully and qualitative data analysis of selected participants for examining conceptions of STEM education. In the study, the interviews of STEM education researchers (N=9) and middle school teachers (N=9) were analyzed by inductive and deductive coding thematic analysis. The participants that were selected for the study, identified based on TSESSP results including the participants having the scores one SD higher than the mean, around the mean, and one SD lower than the mean.

The results of this study were analyzed in qualitative methods. Qualitative data that came from The STEM Education Conceptualization Level Determination Interview Protocol (SECLDIP), was used to assess the conception of the participants. The qualitative data of this study was obtained by conducting semi structure interviews. The interviews of the participants were transcribed and coded to determine patterns in the answers of STEM education researchers and middle school teachers about conception of STEM education.

Research questions were discussed in order to investigate STEM education researchers' and middle school teachers' features of STEM education conception. The similarities and differences were identified through qualitative data analysis by creating codes to reveal patterns between two groups of participants. Özdemir, Yaman and Vural (2018) conducted a study to investigate if there is any significant difference between the TSESSP scores of pre-service teachers who have or do not have detailed knowledge about STEM education and pre-service teachers who have participated and have not participate in the STEM-related activity. As a result of the analysis, a significant difference was found between the self-efficacy beliefs of the teacher candidates who have detailed knowledge about STEM education and those who do not. Likewise, a significant difference was found between the self-efficacy of the pre-service teachers who did activities related to STEM education and those who did not do activities related to STEM education. This research also aims to deepen those findings obtained by Özdemir, Yaman and Vural (2018) by investigating STEM education conceptions of participants who have different levels of self-efficacy beliefs of STEM education. This research also aims to find the similarities and differences in STEM education conception between teachers and researchers to gain more insight about theory-practice gap (Korthagen, 2007) at conceptualization level.

The semi structured interview protocol was conducted with the participants through interviews. The answers of the participants for the interview questions were evaluated under 6 main themes namely, *definition, goals, outcomes, nature and scope of integration, implementation and visualizations of STEM education* by deductive coding thematic analysis.

For the theme of definition, STEM education researchers explained that STEM education was real-life problem solving and integration of disciplines. On the other hand, middle school teachers explained that STEM education was integration of disciplines, product making and used to reinforce the learned topics. The participants from both groups defined STEM education as the integration of disciplines, yet STEM education researchers defined STEM education as real-life problem solving while middle school teachers defined STEM education as a mean to make products to display with reinforcing the learned topics. Based on Moore and Tamara, et al. (2015), STEM education has 5 core characteristics including *development of 21st century skills and solving a real-world problem or task*. STEM education researchers put great emphasis on real world problem solving when they define STEM education rather than middle school teachers based on the qualitative data. Ring-Whalen *et al.* (2018) also identified two content-agnostic components of STEM education relating to the need of providing 21st century skills and real-world linkages. In this study, STEM education researchers put great emphasis on real world problem solving when they define STEM education. However, teachers should also be aware of the important aspect of STEM education since they are the ones who integrate STEM education in their classrooms.

For the category of students' goals, STEM education researchers indicated that the goals for students were improving 21st century skills and raising competent individuals while middle school teachers most frequently indicated that the *goals* for students were being aware of real-life implementation of disciplinary concepts. Kloser *et al.* (2018) concluded in their study that affective measures were the most often existing views regarding goals of STEM education among the instructors. On the other hand, the participant teachers in this study mentioned mostly the code of *being aware of real-life implementation of disciplinary concepts* meaning that participants conceptualize STEM education as a means to connect concept to real life. The teachers indicated that students learn the disciplinary concepts from the book with actually understanding how to use it in real life context especially the concepts in mathematics and science. They explained that students always ask where to use the information learned in the lesson. With STEM education, it would be clearer to students to practical aspect of disciplinary concepts. Despite the fact that "real-life" application of STEM is organically integrated, most K-12 educators do not teach the topic in this manner (Breiner *et al.*, 2012). Some teachers believed that real-world linkages could not be appropriate for all courses or topics, and that these connections could actually limit students' learning of abstract issues, according to study conducted by Wuolle (2016). Teachers may avoid making real-world connections due to a lack of ideas, training, and resources (Gainsburg, 2008). As a result, teachers may not recognize the ideal strategy to use a real-world problem-solving technique in STEM education (Woo, Ashari, Ismail, and Jumaat, 2018). Participants in discipline-focused PD can complete activities that are directly related to what they teach or are similar enough that implementing to their own teaching is easier (Henderson et al. 2011). This indicates that teachers are putting their newly developed concepts and practices into situations that are fairly similar to how they were taught. Therefore, developing professional development programs particularly for departmental in-service teachers might be an effective way to handle the problem of connecting real life scenarios and problems in classroom regarding STEM education.

STEM education researchers explained that raising awareness in each disciplinary perspective for real life problem solving and cooperation among field teachers were the goals for teachers. Middle school teachers explained that gaining knowledge of other disciplines were the goals for teachers. STEM education researchers indicate in almost each theme that STEM education goals centered around real-life problem solving. LaForce et al. (2014) states that teachers design specific projects that immersed students in actual or real-world situations, necessitating a thorough mastery of the STEM disciplines' material and processes. Given the additional time commitment, administrators have an essential role in supporting professional STEM training, according to this study. STEM schools, according to recent research, are highly collaborative workplaces that benefit from distributed leadership models and a redefining of the relationship between instructors, students, and knowledge (Spillane, Lynch, and Ford, 2016). Therefore, in order to achieve the goals for teachers stated by the STEM education researchers and middle school teachers, professional development of the teachers for STEM education is crucial element. The goals for teachers also need to be defined before the professional development for teachers to develop their knowledge and practices. Also creating time for teachers to collaborate is so significant for the implementation.

For the category of outcomes for students, Honey *et al.* (2014) stated that one of the outcomes for students includes the ability to make connection among STEM disciplines. Both groups indicated that students gain holistic perspective which enable them to connect disciplines. For the outcomes for teachers, STEM education researchers explained that improving pedagogical content knowledge, cooperation among field teachers and problem-based teaching as the outcomes for teachers and their practice. Middle school teachers explained that active teaching process, gaining knowledge of other disciplines, cooperation among field teachers and improving pedagogical content knowledge were the goals for teachers. Shernoff and collogues (2017) stated that the most common assistance needed by teachers was time to discuss and plan. In their research, instructors responded that more time is needed for different topic area teachers to collaborate in order to take integrated STEM education to the next level. The lack of collaboration also inhibits teachers to develop certain understanding of other disciplinary fields and execute planned problem-based teaching. Since STEM education researchers and middle school teachers commonly agree that one of the outcomes of STEM education is collaboration between field teachers, stakeholders need to consider creating enough amount of time to plan for field teachers together with their heavy schedule.

For the theme of *nature and scope of integration*, STEM education researchers mostly explained STEM education is the *natural connection of disciplines in a real life-problem.* However, middle school teachers indicated that STEM education was *connection of concepts from disciplines.* This part of the study indicates and reveals the conceptual understanding of two different groups. STEM education encompasses many disciplines (an interdisciplinary, integrated, or trans-disciplinary approach) and frequently feature a project- or problem-based approach linked to realistic or real-world situations (Peters-Burton et al. 2014). Opportunities for student growth in twenty-first century abilities like as cooperation, critical thinking, creativity, responsibility, resilience, and leadership are inherent in problem- and project-based learning

(Geisinger, 2016). These projects frequently include collaborations with STEM practitioners and other members of the community who can assist students in making connections (Holmlund *et al.* 2018). Therefore, the connection of disciplines in STEM education can be actualized around real-life problem as STEM education researchers stated. However, middle school teachers mostly indicated that STEM education can be actualized by making the connection between disciplinary concepts.

Under the category of duration, size and complexity of practice, STEM education researchers expressed that it depends different aspects such as the grade level, context and readiness level of students with avoiding giving rigid answers for the duration and size of practice. Middle school teachers also explained it depends on the grade level and readiness level of students for the complexity of a practice yet, they indicated that 1 class hour is not enough for conducting STEM activities. Therefore, they gave certain durations for the practices to be conducted. Shernoff and collogues (2017) explained that middle and high school teachers struggle to find shared blocks of time where instructors from various STEM disciplines could cooperate, plan, and execute integrated programs. They also stated that there is insufficient instructional time for STEM projects due to the large amount of information to cover. Instructors in their research claimed that there is a lot of pressure to make sure children are prepared for standardized exams, and that test preparation takes time away from innovative and integrative kinds of education like problem-based or project-based learning.

For the instructional design, almost all STEM education researchers explained the process of designing an instruction such as deciding on learning objectives, deciding on assessment, deciding on practice, depends on need analysis, lesson plan preparation and deciding on teaching techniques and methods. On the other hand, middle school teachers expressed deciding on materials, arrangement of the groups and deciding on practice. Stohlmann *et al.* (2012) explained the strategies in their study of *Considerations for Teaching Integrated STEM Education* including support, teaching, efficacy and materials. Each aspect completes each other to conduct and actualize teaching integrated STEM education. Based on their study, it can be concluded that STEM education researchers mainly focused on teaching aspect of the planning such as lesson planning and classroom practices. However, middle school teachers mainly focused on the materials aspects which also includes the arrangement of groups. If there isn't a planned strategy to implementation, the integration of STEM topics may not be more successful. Well-integrated curriculum, on the other hand, allows students to learn in more relevant and interesting ways, fosters the application of higher-level critical thinking abilities, enhances problem-solving skills, and boosts retention (Stohlmann *et al.* 2012). Building a comprehensive strategy to incorporating STEM concepts necessitates a solid understanding of how students learn and apply STEM concepts.

For the integration in class, STEM education researchers indicated that STEM education was an integration of disciplinary concepts and practices around a real-life problem and skills around disciplinary practices such as engineering. On the other hand, middle school teachers indicated that STEM education was an integration of disciplinary concepts and practices around a product. The conceptualization for classroom integration would enlighten the difference of the two groups perspectives. Roehrig *et al.* (2021) explained seven key characteristics of STEM education including focused on real-world problems, engagement in engineering design, context and content integration, engagement in authentic STEM practices and 21st century skills (p.4). The integration in class should include these characteristics while planning. According to research, instructors' conceptions have an impact on their practice (Trigwell, Prosser, and Waterhouse, 1999). Diverse methods to teaching have been linked to varied approaches to learning so how a teacher conceptualize about teaching may have a big impact on how students learn in the classroom (Ring-Whalen *et al.*, 2018). Therefore, if the middle school teachers indicate that integration of STEM education in classroom might be actualized by a product instead of real-life problems and practices such as engineering, STEM education might be simply implemented as any product making without deeper connections. Professional development had a beneficial influence on teachers' conceptions of STEM education, according to Du *et al.* (2019), and it also made them aware of the assistance they required for implementation.

Apart from the textual data, the visualizations of STEM education models differ across the groups. For STEM education researchers, transdisciplinary and interconnected models mostly appeared. On the other hand, middle school teachers' visualizations appeared mostly as interconnected and siloed. All of the participants indicated that the disciplines are tightly connected to each other, yet it is revealed that each participant has a different perspective how to represent those connections through mental models. These models revealed that individual might differ in terms of the reflection for roles and the relation between STEM disciplines. Based on Bybee's (2013) visualizations, transdisciplinary visualizations are more focused on the real-world problem-solving nature of STEM. However, mental models revealed that middle school teachers fail to represent STEM education's real-life connection but only managed to show the integration of disciplines through classroom practices. It is important to introduce models of STEM educations that represent transdisciplinary connections for deeper understanding. Radloff and Guzey (2016) stated that not only is there a lot of variance in how STEM education is defined, but there are also just a few STEM education visualizations accessible in the literature. Comprehensive visualizations may aid future STEM education instructors in conceptually internalizing STEM education content by providing effective visual frameworks. Excellent STEM education visualizations, when combined with effective pedagogical training, might greatly aid future STEM education teacher development.

Based on the qualitative analysis for the research question one, it was identified that there were similarities between the STEM education researchers and middle school teachers at some aspects in the conception of STEM education since the teachers practice STEM education in their classes. However, it was clear from the analysis of the data that STEM education researchers present theoretical understanding with giving examples reflecting integrated nature of STEM education including real life problem solving. STEM education researchers also mostly indicated that 21st century skill development is so crucial. The conceptions of middle school teachers also consisted the understanding that STEM education is an interdisciplinary practice, however their understanding is composed of classroom practices rather than the theoretical components and aspects. The need of bridging and overcoming this gap has been repeatedly emphasized, and it has been suggested that practitioners should be essential stakeholders, working as coproducers with academics to develop information that may close the gap (Kieren, Krainer, and Shaughnessy, 2013). Teachers may be able to better share a common awareness and concentrate on professional development which emphasizes and links the problem-based, integrated, and contextualized character of integrated STEM (Kloser *et al.* 2018).

The data of participants who had different levels of self-efficacy beliefs were also evaluated. Middle school teachers who had different levels of self-efficacy beliefs, examined regarding their STEM education conception, yet the answers did not reveal significant difference between the codes for the categories. In order to address the reasons for the difference in self-efficacy beliefs, there should be more researchers done including other aspects that might have an impact on self-efficacy beliefs. The difference might be caused by their demographic background because the group with higher self-efficacy beliefs received professional training regarding STEM education for a long duration in recent years. However, as the self-efficacy beliefs reduced across the groups, it was identified that the statue of receiving a professional development decreases and the amount of training duration decreases.

The STEM education researchers who had different levels of self-efficacy beliefs, examined regarding their STEM education conception and it was revealed that STEM education researchers who had scores one SD higher than the mean on TSESSP were able to give more comprehensive answers for the implementation of STEM education. Their answers were broad from the theoretical aspect and from the practical implementation of the STEM education in the classroom setting. The relationship between the implementation aspect of STEM education conception and self-efficacy beliefs of STEM education would be investigated to form more comprehensive understanding. The difference between TSESSP scores might be caused by their demographic background because the group with higher self-efficacy beliefs have published more than 10 articles and they have been provided STEM education training. As the self-efficacy belief scores increased, the published articles about STEM education also decreases and STEM education researchers who had scores one SD lower than the mean on TSESSP also did not provide training regarding STEM education.

7.1. Limitations

There are some limitations of this study that were identified. One of the limitations is that from the participant aspect. The interviews with the participants were conducted through online meeting tools. During the interviews, there might be a possibility that the participants could reach out resources from online or from their surroundings. In order to reduce that possibility, participants were monitored by the researcher through the entire interview.

The second limitation concerns about the comprehensive aspect of this study. The data of this study was obtained from only middle school teachers who work in private school setting. Research participants from both private and public schools could be more comprehensive.

As the last limitation, participant of this study might have been aware of Bybes's (2013) article and representations. Therefore, it is possible that the visualizations might not reflect their own perspectives. This study assumed that the mental models of participants reflect their own conception of STEM education.

7.2. Suggestions

When the literature was reviewed, it was discovered that Gardner, Glassmeyer and Worthy (2019) used *Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education* developed by Honey, Pearson and Schweingruber (2014) as theoretical background in order to design professional development program for in service teachers. As a result of their study, it was concluded that professional development program provided gains in self-efficacy beliefs of STEM education.

This study could provide a direction for further research to investigate conception of STEM education by using *Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education* developed by Honey, Pearson and Schweingruber (2014). The investigation for STEM education conceptions could serve as need analysis in order to establish more profound professional development programs that might lead to increase in self-efficacy beliefs of STEM education. If the needs of the teachers are evaluated based on their conceptions of STEM education, the design of professional development using the *Descriptive Framework Showing General Features and Subcomponents of Integrated STEM Education* could be more need oriented.

The second suggestion for further research to investigate how the visualization help individuals gain conceptual understanding of STEM education. Johnson Laird (1983) stated that humans comprehend the world by constructing models of it in their cognition. Individuals' understanding of phenomena or environments is influenced by these models, which in turn impact how they behave. Mental models necessitate linguistic and symbolic representations that indicate how concepts inside the mental model are connected to one another (Kloser et. al., 2018). The visualizations of STEM education based on literature can be contracted to develop STEM education conceptions of teachers. It would be an important aspect for the design of professional development programs to include visualizations and explicit explanations of those visualizations in order to achieve more integrated STEM education in practices.

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APPENDIX A: TEACHER SELF-EFFICACY SCALE FOR STEM PRACTICES

Table A.1. Teacher Self-Efficacy Scale for STEM Practices.

Madde No	Madde	Hiçbir Zaman	Nadiren	Bazen	Sık Sık	Her Zaman
1	STEM yaklaşımına özgün sonuçlara ulaşabilirim.					
2	STEM etkinliği tasarlarken gerekli olan bilimsel süreç becerileri konusunda akademik olarak yeterliyim.					
3	STEM uygulamalarında kullanılmak üzere modeller ve materyaller geliştirebilirim.					
4	STEM ile ilgili iyi bir etkinlik tasarlayabilirim.					
5	STEM ile ilgili etkinliklerin sonuçlarını rahatça yorumlayabilirim.					
6	STEM uygulamalarıyla ilgili projelerde görev alabilecek düzeydeyim.					
7	Öğrencilerin STEM ile ilgili sorularını yanıtlayabilirim.					
8	STEM etkinliklerini günlük hayata uyarlayabilirim.					
9	Zeka alanını geliştirici STEM etkinlikleri tasarlayabilirim.					
10	STEM etkinliklerinde kazandırılması gereken hedefleri öğrenci ve çevre özelliklerine uygun olarak belirleyebilirim.					
11	Bir STEM etkinliği yapmaya karar verdiğimde hemen işe girişirim.					
12	STEM uygulamalarında kendimi yeterli hissediyorum.					
13	STEM uygulamalarında eleştirel düşünmeyi sağlayabilirim.					
14	STEM kavramlarına ve terimlerine hakim olduğumu düşünüyorum.					
15	STEM etkinliklerinde uyguladığım adımları öğrencilerime rahatça anlatabilirim.					
16	STEM uygulamaları ile ilgili planlar yaparken onları hayata geçirebileceğimden eminim.					
17	STEM uygulamalarında kendime güvenirim.					
18	STEM uygulamaları çok zor görünse de yapmaya çalışırım.					

APPENDIX B: STEM EDUCATION CONCEPTUALIZATION LEVEL DETERMINATION INTERVIEW PROTOCOL

Demografik Bilgiler

1. Adınız-Soyadınız:

2. Yaşınız:

3. Branşınız:

4. Şimdiye kadar öğretmenlik yaptığınız seviyeler:

5. Toplam öğretmenlikteki tecrübe yılınız:

6. Çalıştığınız okul:

7. Mevcut eğitim öğretim döneminde derslerine girdiğiniz sınıf seviyesi?

8. Mevcut eğitim öğretim döneminde sınıflarınızda STEM ya da Türkçeye Adapte Edilmiş Haliyle FeTeMM eğitimini uyguluyor musunuz? (Cevabınız evet ise kaç senedir STEM eğitimini uyguluyorsunuz?):

9. E-mail adresiniz:

10. STEM yaklaşımına ilişkin daha önce herhangi bir eğitim aldınız mı?

11. Aldıysanız, ne zaman? Ne kadar süreyle?

STEM Eğitimi Kavramsallaştırma Düzeyi Belirleme Soruları

12. STEM eğitimini kendi sözcükleriniz ile nasıl tanımlarsınız?

13. STEM eğitiminin <u>amaçları</u> nedir?

a) Öğrenciler için

b) Öğretmenler için

14. STEM eğitimi uygulanan bir eğitim öğretim ortamında ne tür çıktılar gözlemlenebilir?

a) Öğrenciler açısından

b) Öğretmenler açısından

15. STEM eğitimi uygulamaya başladıktan sonra sınıf içi ders uygulamalarınızda ne gibi değişimler / değişiklikler gözlemlediniz?

16. Uyguladığınız STEM eğitimi etkinliklerinde yer alan disiplinlerin arasında nasıl bir ilişki vardır? (Ne çeşit bağlantılar gözlemlenebilir?-)

17. Bir STEM etkinliğinin karmaşıklığı nasıl olmalıdır? (Ne kadar sürede uygulanmalıdır)

18. STEM eğitimi uygulanmadan önce nasıl bir öğretim tasarımı yapılmalıdır?

19. STEM yaklaşımındaki tüm disiplinlerin ilişkilendirilmesini içeren bir etkinlik uygulamasında disiplinlerin nasıl ilişkilendirildiğini açıklayınız.

20. Şimdi sizden STEM eğitimini kafanızda görsel olarak canlandırmanızı istiyorum. Kafanızda canlandırdığınız görsel nasıl bir model? Aşağıya canlandırdığınız modeli S, T, E ve M harflerini kullanarak ve bunlar arasındaki ilişkiyi göstererek modelinizi çiziniz:

21. Yukarıdaki görseli neden bu şekilde çizdiğinizi açıklayınız:

Figure B.1. STEM Educatıon Conceptualization Level Determination Interview Protocol.

APPENDIX C: APPROVAL OF INSTITUTIONAL REVIEW BOARD FOR RESEARCH WITH HUMAN SUBJECTS OF BOĞAZIÇI UNIVERSITY

Evrak Tarih ve Sayısı: 05.11.2021-36927

T.C.
BOĞAZİÇİ ÜNİVERSİTESİ REKTÖRLÜĞÜ
Fen Bilimleri ve Mühendislik Alanları İnsan Araştırmaları Etik Kurulu
(FMİNAREK)

Sayı : E-84391427-050.01.04-36927 05.11.2021
Konu : 2021/22 Kayıt no'lu başvurunuz hakkında

Sayın Doç. Dr. Sevil AKAYGÜN
Matematik ve Fen Bilimleri Eğitimi Bölüm Başkanlığı - Öğretim Üyesi

"STEM EĞİTİMİ ARAŞTIRMACILARININ VE ORTAOKUL ÖĞRETMENLERİNİN STEM EĞİTİMİNE İLİŞKİN KAVRAMSALLAŞTIRMA DÜZEYİ VE ÖZ YETERLİLİKLERİNİN KARŞILAŞTIRILMASI (A COMPARISON OF STEM EDUCATION RESEARCHERS' AND MIDDLE SCHOOL TEACHERS' CONCEPTIONS AND SELF EFFICACY OF STEM EDUCATION) " başlıklı projeniz ile Boğaziçi Üniversitesi Fen Bilimleri ve Mühendislik Alanları İnsan Araştırmaları Etik Kurulu (FMİNAREK)'e yaptığınız 2021/22 kayıt numaralı başvuru 01.11.2021 tarihli ve 2021/09 No.lu kurul toplantısında incelenerek etik onay verilmesi uygun bulunmuştur.

Bu karar tüm üyelerin toplantıya on-line olarak katılımıyla ve oybirliği ile alınmıştır. COVID-19 önlemleri nedeniyle üyelerden ıslak imza alınamadığından bu onam mektubu tüm üyeler adına Komisyon Başkanı tarafından e-imzalanmıştır.

Saygılarımızla bilginize sunarız.

Prof. Dr. Tınaz EKİM AŞICI
Başkan

Bu belge, güvenli elektronik İmza ile imzalanmıştır.

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Figure C.1. Approval of Institutional Review Board For Research With Human Subjects Of Boğaziçi Unıversity.

APPENDIX D: PARTICIPANT INFORMATION AND CONSENT FORM

Araştırmanın adı: STEM Eğitimi Araştırmacılarının ve Ortaokul Öğretmenlerinin STEM Eğitimine İlişkin Kavramsallaştırma Düzeyi ve Öz Yeterliliklerinin Karşılaştırılması
Proje Yürütücüsü/Araştırmacının adı: Doc. Dr. Sevil Akaygün ve Merve Türkyılmaz Sarıgül
Adresi: Boğaziçi Üniversitesi
E-mail adresi: sevil.akaygun@boun.edu.tr , merveturkyilmaz94@gmail.com
Telefonu: 0538 410 85 74

Sayın öğretmen/araştırmacı,

Ben, Boğaziçi Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü yüksek lisans öğrencisi Merve Türkyılmaz Sarıgül. Doç. Dr. Sevil Akaygün danışmanlığında "STEM Eğitimi Araştırmacılarının ve Ortaokul Öğretmenlerinin STEM Eğitimine İlişkin Kavram ve Öz Yeterliliklerinin Karşılaştırılması" adı altında bilimsel bir araştırma projesi yürütmekteyim. Bu çalışmanın amacı, STEM eğitimi araştırmacılarının (STEM eğitimi alanında tez, doktora tezi veya makale yazmış kişiler) ve ortaokul fen, matematik ve bilişim teknolojileri öğretmenlerinin STEM eğitimine ilişkin kavramsallaştırma düzeyi ve öz yeterliklerini incelemektir. Bu araştırmada bana yardımcı olmanız için siz ortaokul fen, matematik ve bilişim teknolojileri öğretmenlerini/ araştırmacıları de/da projemize davet ediyorum. Kararınızdan önce araştırma hakkında sizi bilgilendirmek istiyorum. Bu bilgileri okuduktan sonra araştırmaya katılmak isterseniz lütfen bu formu imzalayıp online mail olarak tarafıma ulaştırınız.

Bu araştırmaya katılmayı kabul ettiğiniz takdirde iki aşamalı bir süreçten geçeceksiniz. İlk aşamada, STEM öz-yeterliliği amaca bağlı olarak literatürden elde edilen 18 soruluk bir ölçek ile değerlendirilecektir. Bu anketi doldurmak en fazla 5 dakikanızı alacaktır. Bu aşamada katılımcıların sonuçları ANOVA varyans analizi kullanılarak karşılaştırılacaktır. STEM eğitimi ile ilgili öz-yeterlik ölçeğinin sonucuna dayalı olarak, STEM eğitimi araştırmacıları ile ortaokul fen, matematik ve bilişim teknolojileri öğretmenleri karşılaştırılarak, araştırmacılar ve öğretmenler arasında anlamlı bir fark olup olmadığı ortaya çıkarılacaktır.

Kıyaslamanın sonuçlarına göre katılımcıların içinden belirli bireyler seçilerek, STEM eğitimi ile ilgili kavramsallaştırma düzeyi değerlendirilecektir. STEM eğitimi konusundaki kavramsallaştırma düzeyini incelemek ve araştırmacılar ile ortaokul öğretmenlerinin STEM kavramsallaştırma düzeylerinin birbirinden nasıl farklılaştığını araştırmak için araştırmacı tarafından geliştirilen anket uygulanacaktır. Bu anket 30 dakikalık görüşmeler sonucu online uygulanacaktır ve görüşmeler kayıt altına alınacaktır. Ayrıca, araştırmacılar ve ortaokul öğretmenleri arasındaki STEM eğitimi kavramsallaştırma düzeyinin karşılaştırılması, STEM eğitimi ile ilgili öz-yeterlik ölçeğinin çıktılarını değerlendirmek için kullanılacaktır.

Bu araştırma bilimsel bir amaçla yapılmaktadır ve katılımcı bilgilerinin gizliliği esas tutulmaktadır. Online görüşmelerin video kayıtlarında katılımcıların ismi yerine bir numara kullanılacaktır. Videolar araştırma projemiz süresince benim tarafından muhafaza edilip araştırma sona erdiğinde silineceklerdir.

Bu araştırmaya katılmak tamamen isteğe bağlıdır. Katıldığınız takdirde çalışmanın herhangi bir aşamasında herhangi bir sebep göstermeden onayınızı çekmek hakkına da sahipsiniz. Araştırmadan çekildiğiniz taktirde size ait toplanan veriler tamamen silinecektir. Araştırma projesi hakkında ek bilgi almak istediğiniz takdirde lütfen benimle temasa geçiniz (Telefon: 0538 410 85 74). Katılımcılar ayrıca bilgi almak için Boğaziçi Üniversitesi Fen Bilimleri ve Mühendislik Alanları İnsan Araştırmaları Etik Kurulu'na FMİNAREK (fminarek@boun.edu.tr) danışabilirler.

Eğer bu araştırma projesine katılmasını kabul ediyorsanız, lütfen bu formu imzalayıp online mail olarak tarafıma ulaştırınız.

Ben, (katılımcının adı) ...., yukarıdaki metni okudum ve katılmam istenen çalışmanın kapsamını ve amacını, gönüllü olarak üzerime düşen sorumlulukları tamamen anladım. Çalışma hakkında soru sorma imkânı buldum. Bu çalışmayı istediğim zaman ve herhangi bir neden belirtmek zorunda kalmadan bırakabileceğimi ve bıraktığım takdirde herhangi bir olumsuzluk ile karşılaşmayacağımı anladım.

Bu koşullarda söz konusu araştırmaya kendi isteğimle, hiçbir baskı ve zorlama olmaksızın katılmayı kabul ediyorum.

Formun bir örneğini aldım / almak istemiyorum (bu durumda araştırmacı bu kopyayı saklar).

Katılımcının Adı-Soyadı:..
İmzası:..
Adresi (varsa Telefon No, Faks No):...
....
Tarih (gün/ay/yıl):...../......./.............
Araştırmacının Adı-Soyadı: Doc. Dr. Sevil Akaygün ve Merve Türkyılmaz Sarıgül
İmzası:

Tarih (gün/ay/yıl):...../......./.............

Figure D.1. Participant Informatıon and Consent Form.

APPENDIX E: THE FINAL SCORES OF THE PARTICIPANTS ON TSESSP

Table E.1. The Final Scores of the Participants on TSESSP.

PARTICIPANTS	FIELDS OF STUDY	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	TSESSP SCORES
A1	SCIENCE	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
A2	SCIENCE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
A3	SCIENCE	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4.06
A4	SCIENCE	4	4	5	5	4	5	5	5	4	4	4	5	5	5	5	5	5	4	4.61
A5	SCIENCE	4	4	5	5	4	5	4	5	4	4	5	4	4	4	5	5	4	5	4.44
A6	SCIENCE	4	4	5	5	5	5	5	5	4	4	3	4	4	5	5	5	5	4	4.50
A7	INFORMATION TECHNOLOGIES	4	5	3	4	5	5	5	5	4	5	3	5	4	5	4	4	5	4	4,39
A8	SCIENCE	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5	4.89
A9	MATHEMATICS	4	3	4	4	3	3	3	4	3	4	2	4	4	5	3	3	4	4	3.56
A10	SCIENCE	4	5	4	5	5	5	5	5	4	4	5	4	4	5	5	4	4	4	4.50
A11	INFORMATION TECHNOLOGIES	4	4	4	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	3.889
A12	MATHEMATICS	3	4	4	4	4	5	3	4	4	4	3	4	4	3	4	3	4	3	3.72
A13	SCIENCE	4	4	4	5	5	4	4	4	3	4	3	4	4	4	5	4	4	3	4
A14	SCIENCE	3	5	3	5	5	5	5	3	5	5	3	5	5	5	5	3	5	3	4.33
A15	SCIENCE	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
A16	SCIENCE	5	4	4	5	4	5	5	5	4	5	4	5	5	5	4	5	5	5	4.67
A17	SCIENCE	4	5	5	5	5	5	5	5	5	4	5	5	4	4	5	5	5	5	4.78
A18	SCIENCE	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5	4.89
A19	SCIENCE	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
A20	MATHEMATICS	4	5	5	5	5	5	5	5	5	4	3	5	5	5	5	5	5	3	4.67
A21	MATHEMATICS	5	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5	4.89
A22	INFORMATION TECHNOLOGIES	3	5	4	4	4	3	3	4	3	3	2	3	3	3	3	3	3	3	3.28
A23	INFORMATION TECHNOLOGIES	4	5	4	4	4	4	5	5	4	5	4	5	3	4	4	5	5	4	4.33
A24	MATHEMATICS	3	4	5	4	5	5	5	4	3	5	4	5	4	5	5	4	4	4	4.33
A25	INFORMATION TECHNOLOGIES	3	4	3	3	5	4	4	3	3	4	3	4	2	4	4	3	4	3	3,5
A26	MATHEMATICS	4	5	4	4	4	4	4	4	4	4	3	4	4	5	5	4	4	4	4.11
A27	INFORMATION TECHNOLOGIES	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
A28	INFORMATION TECHNOLOGIES	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
A29	INFORMATION TECHNOLOGIES	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3.94
A30	INFORMATION TECHNOLOGIES	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
FO1	SCIENCE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
FO2	SCIENCE	3	3	4	4	4	2	4	4	2	4	5	2	4	2	4	5	5	5	3.67
FO3	SCIENCE	3	3	4	4	4	3	4	3	3	3	4	3	3	3	4	3	4	4	3.44
FO4	SCIENCE	4	5	3	3	4	3	5	5	3	5	4	4	4	5	5	4	4	5	4.17
FO5	SCIENCE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
FO6	SCIENCE	4	4	3	4	4	3	4	4	4	4	3	3	4	3	4	4	3	4	3.67
FO7	SCIENCE	5	3	4	4	4	4	3	4	3	3	4	4	4	3	3	4	4	3	3.67
FO8	SCIENCE	4	4	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	5	4.78
FO9	SCIENCE	5	5	4	4	4	3	5	5	4	5	4	5	5	5	5	5	5	5	4.61
FO10	SCIENCE	5	4	5	5	5	5	5	5	4	5	4	4	5	4	5	5	5	5	4.72
MO1	MATHEMATICS	2	4	2	3	4	2	4	4	2	3	2	2	2	2	4	3	3	3	2.83
MO2	MATHEMATICS	4	3	3	2	4	3	4	4	2	4	4	2	4	2	4	3	3	4	3.28
MO3	MATHEMATICS	4	5	4	5	5	3	3	4	4	4	4	3	3	3	3	3	3	3	3.67
MO4	MATHEMATICS	4	4	4	3	3	3	4	3	3	4	4	4	2	3	3	2	2	3	3.22
MÖ5	MATHEMATICS	3	5	5	5	5	5	5	5	3	4	3	5	5	5	5	4	5	5	4.56
MÖ6	MATHEMATICS	4	4	3	3	4	3	4	4	3	4	3	4	4	4	4	4	4	4	3.72

Table E.1. The Final Scores of the Participants on TSESSP. (cont.)

PARTICIPANTS	FIELDS OF STUDY	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	TSESSP SCORES
MÖ7	MATHEMATICS	3	4	4	4	4	4	5	5	4	4	5	3	4	3	4	4	4	4	4
MÖ8	MATHEMATICS	4	5	4	3	2	2	4	4	4	4	3	4	4	3	5	5	5	5	3.89
MÖ9	MATHEMATICS	4	3	4	3	3	3	4	4	3	4	4	3	4	3	4	2	3	4	3.44
MÖ10	MATHEMATICS	4	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	4	4	3.89
BÖ1	INFORMATION TECHNOLOGIES	4	4	4	4	3	4	3	4	3	4	4	3	4	3	4	4	4	4	3.72
BÖ2	INFORMATION TECHNOLOGIES	4	5	4	4	5	4	5	4	4	4	4	4	5	5	4	4	4	4	428
BÖ3	INFORMATION TECHNOLOGIES	5	4	4	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	4.78
BÖ4	INFORMATION TECHNOLOGIES	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
BÖ5	INFORMATION TECHNOLOGIES	4	4	4	4	2	5	5	5	5	4	5	4	4	4	5	5	5	5	4.39
A29	INFORMATION TECHNOLOGIES	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3.94
A30	INFORMATION TECHNOLOGIES	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
FO1	SCIENCE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
FO2	SCIENCE	3	3	4	4	4	2	4	4	2	4	5	2	4	2	4	5	5	5	3.67
FO3	SCIENCE	3	3	4	4	4	3	4	3	3	3	4	3	3	3	4	3	4	4	3.44
FO4	SCIENCE	4	5	3	3	4	3	5	5	3	5	4	4	4	5	5	4	4	5	4.17
FO5	SCIENCE	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
FO6	SCIENCE	4	4	3	4	4	3	4	4	4	4	3	3	4	3	4	4	3	4	3.67
FO7	SCIENCE	5	3	4	4	4	4	3	4	3	3	4	4	4	3	3	4	4	3	3.67
FO8	SCIENCE	4	4	5	5	5	5	5	5	5	5	5	4	5	5	5	4	5	5	4.78
FO9	SCIENCE	5	5	4	4	4	3	5	5	4	5	4	5	5	5	5	5	5	5	4.61
FO10	SCIENCE	5	4	5	5	5	5	5	5	4	5	4	4	5	4	5	5	5	5	4.72
MO1	MATHEMATICS	2	4	2	3	4	2	4	4	2	3	2	2	2	2	4	3	3	3	2.83
MO2	MATHEMATICS	4	3	3	2	4	3	4	4	2	4	4	2	4	2	4	3	3	4	3.28
MO3	MATHEMATICS	4	5	4	5	5	3	3	4	4	4	4	3	3	3	3	3	3	3	3.67
MO4	MATHEMATICS	4	4	4	3	3	3	4	3	3	4	4	4	2	3	3	2	2	3	3.22
MÖ5	MATHEMATICS	3	5	5	5	5	5	5	5	3	4	3	5	5	5	5	4	5	5	4.56
MÖ6	MATHEMATICS	4	4	3	3	4	3	4	4	3	4	3	4	4	4	4	4	4	4	3.72
MÖ7	MATHEMATICS	3	4	4	4	4	4	5	5	4	4	5	3	4	3	4	4	4	4	4
MÖ8	MATHEMATICS	4	5	4	3	2	2	4	4	4	4	3	4	4	3	5	5	5	5	3.89
MÖ9	MATHEMATICS	4	3	4	3	3	3	4	4	3	4	4	3	4	3	4	2	3	4	3.44
MÖ10	MATHEMATICS	4	4	4	4	4	4	3	4	3	4	4	4	4	4	4	4	4	4	3.89
BÖ1	INFORMATION TECHNOLOGIES	4	4	4	4	3	4	3	4	3	4	4	3	4	3	4	4	4	4	3.72
BÖ2	INFORMATION TECHNOLOGIES	4	5	4	4	5	4	5	4	4	4	4	4	5	5	4	4	4	4	428
BÖ3	INFORMATION TECHNOLOGIES	5	4	4	5	5	5	5	5	4	5	5	5	5	5	5	4	5	5	4.78
BÖ4	INFORMATION TECHNOLOGIES	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
BÖ5	INFORMATION TECHNOLOGIES	4	4	4	4	2	5	5	5	5	4	5	4	4	4	5	5	5	5	4.39
BÖ6	INFORMATION TECHNOLOGIES	4	4	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	5	4.11
BÖ7	INFORMATION TECHNOLOGIES	4	5	4	5	5	4	5	5	4	5	5	5	5	4	5	5	5	5	4.72
BÖ8	INFORMATION TECHNOLOGIES	4	4	3	3	4	3	4	4	4	4	4	3	4	4	4	4	4	4	3.78
BÖ9	INFORMATION TECHNOLOGIES	4	3	3	4	4	5	4	4	3	3	3	5	3	2	3	4	4	4	3.61
BÖ10	INFORMATION TECHNOLOGIES	4	4	5	5	5	4	5	5	3	4	3	4	4	4	4	3	4	4	4,11