A TURKISH ADAPTATION OF THE STEM COMPETENCY BELIEFS INSTRUMENT

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A TURKISH ADAPTATION OF THE STEM COMPETENCY BELIEFS INSTRUMENT

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DECLARATION OF ORIGINALITY

I, Cansu Demirbağ, certify that

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ABSTRACT

A Turkish Adaptation of the STEM Competency Beliefs Instrument

Achievement on science, technology, engineering and mathematics (STEM) education is important for the economic developments of countries. According to the social cognitive theory, the self-efficacy beliefs are a core construct which is a crucial predictor of achievement (Bandura, 1986). Self-efficacy beliefs are described as "people's judgments on their own capabilities for specific performance" (Bandura, 1986). In order to measure the self-efficacy variables in STEM education, STEM Competency Beliefs Instrument was developed by Chen, Cannady, Schunn, and Dorph at 2017. The instrument measures STEM self-efficacy beliefs of 10-14 years old students. This study aimed to adapt the instrument into Turkish and to investigate the validity of the Turkish version. The process consisted of three stages: adaptation of the instrument into a Turkish version based on expert work, a pilot study, and the main study to test the psychometric properties of the Turkish version. The instrument has 12 statements with 4 options for each. With the pilot study, reliability and validity analyses were conducted and the clarity of the items was examined. The result of the main study showed that the reliability of the instrument pointed out good internal consistency. Construct validity analysis showed that, in contrast to the original instrument, the Turkish version of the instrument has two-dimensional structure. The study concluded that the instrument can be utilized for STEM-related research to assess competency beliefs of students.

Keywords: STEM education, Self-Efficacy Beliefs, Instrument Adaptation, Construct Validity

ÖZET

Bilim, Teknoloji, Matematik ve Mühendislik Alanlarında Öz Yeterlik İnanç Ölçeğinin Türkçe'ye Adaptasyonu

Bilim, teknoloji, mühendislik ve matematik (BTMM) eğitimlerinde başarı, ülkelerin ekonomik gelişimleri için önemlidir. Sosyo-bilişsel teoriye göre, öz yeterlik inançları başarıyı etkileyen önemli faktörlerden biridir (Bandura, 1986). Öz yetkinlik inançları "belirli bir performans üzerinde, kişinin kendi yeterliliğine olan yargıları" olarak tanımlanmıştır (Bandura, 1986). Bilim, teknoloji, mühendislik ve matematik öz yeterlik inançları ölçeği Chen, Cannady, Schunn ve Dorph (2017) tarafından oluşturulmuştur. Bu ölçek ile 10-14 yaş öğrencilerin bilim,teknoloji, matematik ve mühendislik alanlarına karşı öz yeterlilik inançları ölçülmüştür. Bu çalışmada ise, belirtilen ölçeğin Türkçe'ye adaptasyonu ve Türkçe versiyonun geçerliğinin incelenmesi amaçlanmıştır. Çalışma üç aşamadan oluşmaktadır: uzman çalışmalarına dayanarak ölçeğin Türkçe'ye adaptasyonu, pilot çalışma ve Türkçe versiyonun psikometrik özelliklerinin test edildiği ana çalışma. Ölçek 4'er seçenek içeren 12 ifadeden oluşmaktadır. Pilot çalışma (n=77) ile geçerlik ve güvenirlik analizleri yapılarak, ifadelerin anlaşılırlığı incelenmiştir. Ana çalışmada ise (n=330) yapı geçerliği ve güvenirlik analizlerinin sonucu kabul edilebilir değerler elde edilmiştir. Orijinal ölçeğin tersine, Türkçe versiyonunda ölçeğin iki faktörlü olduğu gözlemlenmiştir. Sonuç olarak, adaptasyon süreci tamamlanan bu çalışma, Bilim,Teknoloji, Matematik ve Mühendislik alanındaki çalışmalarda öz yeterlik inançlarını ölçmek üzere kullanılabilir.

Anahtar Sözcükler: BTMM Eğitimi, Öz-yeterlik İnancı, Ölçek Adaptasyonu, Yapı Geçerliği

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CHAPTER 1

INTRODUCTION

Science, technology, engineering and mathematics (STEM) education harks back to the U.S and has gained popularity all over the world. Within the STEM approach, science is regarded as both the knowledge and process of inquiry, in the first place. Secondly, technology is the production of devices to meet the needs of human. As for the third one, engineering is mainly linked to problem-solving processes under determined circumstances. Finally, mathematics is a study of pattern and relationships between numbers, space, and quantities (NRC, 2014). STEM education is defined as the integration of those disciplines as science, technology, engineering, and mathematics in order to solve real-world problems and connection between the communities enabling the development of STEM literacy and economic growth (Breiner et al.,2012; Tsupros, N., R. Kohler, & J. Hallinen, 2009).

STEM education is important for the economic developments of countries. Countries need qualified workforce and innovative productions to keep their positions in a competitive global market. STEM education makes citizens ready for future job positions and enforces the economy of countries (Atkinson & Mayo, 2010; Johnson, Peters-Burton & Moore, 2016; TÜSİAD, 2019).

STEM education aims to develop 21st-century skills, STEM literacy, interest and engagement towards the STEM fields (Gonzalez & Kuenzi, 2012; NRC, 2014). 21st-century skills refer to critical thinking, communication and collaboration, flexibility and metacognition skills (NRC,2011). These skills are enhanced in a STEM classroom with problem solving process for real world situations (Ariyani, Achmad & Nurulsari, 2019). The term STEM literacy is defined as awareness, applicability, and fluency in STEM disciplines and their concepts (Bybee, 2010; Cavalcanti, 2017). STEM education targets to support people who are not interested in STEM career with STEM literacy. Also, increasing interest and engagement towards STEM fields to work or study is another goal of STEM education. In brief, STEM education upskills people to be smart consumers and thoughtful citizens who understand the world around them.

In order to achieve the aims of STEM education, an appropriate curriculum for K-12 needs to be designed starting from the very early years (NRC, 2014; TÜSİAD, 2019). Over the 25 years, an increasing number of STEM focused schools established in U.S. They classified the STEM focused schools as selective, inclusive and career and technical educational focused (Bicer & Capraro, 2019). Schools provide student-centered approach with integrating STEM courses into math instruction and gives real-world STEM experiences (Means, Wang,Wei, Lynch, Peters, Young & Allen, 2017). However, many schools have been taught mathematics, science, and technology separately. On the other hand, real-world problems require more than one discipline to solve them. Besides, many subjects in today’s world necessitate working as a team contributing from different disciplines. Therefore, STEM education declares a connected and integrated version of science, technology, engineering and mathematics disciplines and a collaborative learning environment (Johnson, Peters-Burton & Moore, 2016).

Pedagogy of STEM education, in other words the methods of teaching STEM, is another issue which is as crucial as curriculum. Suggestions for teaching STEM in classrooms can be listed as student-centered, open-ended, project- and problem-based approaches (Atkinson& Mayo, 2010; Baran et al., 2015; Chittum et al., 2017; Cifuentes & Ozel, 2008; Han, Capraro & Capraro, 2016; Monterastelli et al., 2011; Ozel, 2008). In addition, inquiry-based learning environment with engineering design thinking is a recommended method for STEM education (Biliar et al.,2014; English, King & Smeed, 2017; NGSS, 2017; Johnson, Peters-Burton & Moore, 2016). Throughout this cohesive approach, contexts are chosen to engage learners in an authentic way. This kind of teaching method supports learners' 21st-century skills, engages them more in class and STEM disciplines increase their interests towards the STEM fields (Chittum et al., 2017; Garg, 2015; Maltese & Tai, 2011; John et al.,2016; Monterastelli et al. 2011).

STEM education research investigates achievement of STEM education goals including 21st century skills and STEM interest and career choices (Chittum et al., 2017; Garg, 2015; ; Gülhan & Şahin, 2016; John et al.,2016; Maltese & Tai, 2011; Monterastelli et al. 2011; Yerdelen, Kahraman & Taş, 2016), and influence of engineering design thinking, problem- and project-based learning and hands-on learning on achievement of STEM goals (Billiar et al.2014; English, King & Smeed, 2017; Han, Capraro & Capraro, 2016). Findings of the studies concluded that integrated STEM education has a positive influence on career choices (Gülhan & Şahin, 2016; Yerdelen, Kahraman & Taş, 2016). Literacy towards STEM fields (Bybee, 2010; Cavalcanti, 2017) and STEM approaches engage learners in-class activities (Baran, Canbazoglu-Bilici, Mesutoglu &Ocak, 2015; Biliar et al., 2014; English, King & Smeed, 2017; Hacıoğlu, Yamak & Kavak, 2016).

STEM education is also important for Turkey since it is a developing country (Akgündüz et al. 2015; TÜSİAD, 2019; OECD, 2017). The reasons above-mentioned for other countries such as a competitive global market and need for innovative productions are also valid and essential for Turkey to have a better economy. Turkish citizens are required to add value to their products in global markets in innovative ways (TÜSİAD, 2019). Therefore, Turkey needs to educate its citizens in STEM fields and equip them with 21st-century skills. To achieve this aim, national curriculum was changed, (MEB, 2018d), STEM institutions and centers were opened (Colakoglu & Gokben, 2017), research about STEM studies and developing programs for master and doctorate degrees were increased (Akgündüz et al, 2015).

The STEM research highlighted the significance of self-efficacy beliefs on STEM (Green & Sanderson, 2018). In other words, self-efficacy beliefs effect on learning performance (Bouffard-Bouchard, Parent & Larivee, 1991; Hidi & Ainley, 2008; Pajares, 1997). Also, self-efficacy beliefs observed as strongly related with gender differences in math and science performance (Sax et al., 2016; Telhed, Backström & Björklund, 2016; Hackett & Betz, 1982; Vincent-Ruz & Schuun, 2017; Zeldin, Britner & Pajares, 2006). Many studies indicated that male students have higher efficacy belief in STEM fields than female students (Kanny, Sax & Riggers-Piehl, 2014; Sax et al., 2016; Telhed, Backström & Björklund, 2016; Zeldin, Britner & Pajares, 2006). These studies claimed that self-doubts, lower performance expectations, male-dominated fields, social persuasions and vicarious experiences about STEM fields, individual backgrounds, family influences and expectations, perceptions towards STEM fields, psychological values, factors and preferences are related with females' lower interests towards STEM fields (Kanny, Sax & Riggers-Piehl, 2014; Telhed, Backström & Björklund, 2016; Zeldin, Britner & Pajares, 2006). Lower self-efficacy beliefs of females towards STEM is needed to be overcome to reduce gender segregation in the fields.

STEM Competency Beliefs instrument which depends on the social cognitive theory of Bandura was constructed by Chen, Cannady, Shun, and Dorph (2017) to measure middle school learners perceived self-efficacy about STEM fields. The instrument was also translated into different languages as Spanish and African (M. Cannady, personal communication, November 12, 2018). Hence, in the present study, confirmatory factor analysis with reliability and validity of the Turkish version of the test were conducted to test the psychometric properties of the Turkish version.

The adaptation process of the study comprised of three parts which are listed as follows: forward and backward translation, pilot study and the main study. In the first part, forward and backward translation of the instrument were completed by the language and field experts. Then, the consensus was established for the Turkish form of the instrument and smooth editing was done. In the second step, a pilot study was conducted to understand the clarity of items presented in the Turkish version of the instrument. Also, reliability and validity analyses were demonstrated. Then, main study was conducted with a larger sample and the data shows the instrument is reliable and valid for further investigation. Also, confirmatory factor analysis was studied, and it validated the instrument with a two-factor structure.

At the end of the study, male and female groups, public and private school groups, STEM-related and not STEM-related job preferences of the participants were compared in terms of their self-efficacy beliefs on STEM. Later, the result of the comparisons will be discussed in detail.

1.1. Rationale of the study

STEM education is significant for the economic developments of countries (Akgündüz et al. 2015; NRC,2014; OECD, 2017; TÜSİAD, 2019). Countries need to keep competitive positions in the global market for a strong economy. To achieve this aim, increased number of students in STEM field careers and better academic performances are needed. According to findings, self-efficacy plays a key role in

STEM performance (Kanny, Sax & Riggers-Piehl,2014). Also, self-efficacy showed a large impact on STEM persistence (Green & Sanderson, 2018).

Characteristics of self-efficient people are listed as resilient and less anxious, solution-oriented, being able to work hard (Pajares, 1997) and having a better control of time and better task focus (Bouffard-Bouchard, Parent & Larivee, 1991). Different from others, self-efficient people attribute their failures to weak strategies or insufficient effort (Bandura, 1999).

In addition, self-efficacy becomes an important predictor for different genders' STEM performance. Males have higher self-efficacy than females towards STEM careers (Hackett & Betz, 1982; Sax et al., 2016; Vincent-Ruz & Schuun, 2017; Zeldin, Britner & Pajares, 2006). Hence, one way of increasing STEM performance and reducing gender segregation in the fields is to decrease the effect of self-efficacy.

From the perspective of Turkey as a developing country, it also needs to integrate STEM education to have a strong economy and a position in the competitive global market. Also, the number of STEM education research papers gained acceleration (Han, Capraro & Capraro, 2016; Hacıoğlu, Yamak & Kavak, 2016; Yerdelen, Kahraman & Taş, 2016). However, to the best of our knowledge, there is not a valid instrument to measure the STEM self-efficacy beliefs in Turkey. It is required to measure the efficacy beliefs of learners in order to design required activities to improve self-efficacy of learners.

Based on the above arguments related to STEM education and self-efficacy of learners on STEM, it is also important to improve STEM education practices and STEM education research in Turkey. However, in Turkish literature, there is no valid instrument to measure the self-efficacy beliefs of learners, so far. Therefore, the current study presents an adaptation of STEM Competency Beliefs Instrument into Turkish version to support the literature.

1.2. Significance of the study

The number of studies related to STEM education has gained acceleration in Turkish literature. Between the years of 2014-2019, 57 master and doctorate theses were written related to STEM education (YOK, 2019). It shows that there is a great interest in STEM education in Turkey. Hence, the instrument presented with the study gives researchers the opportunity to measure an important variable in STEM education which is the learners' self-efficacy beliefs.

Moreover, measuring the efficacy beliefs about STEM education helps researchers and educators with a deeper understanding of STEM performance in Turkey. Measuring the effect of efficacy beliefs on STEM performance, researchers or educators have a chance to create preventive actions and solutions to minimize its negative effects on learners' performance. For instance, educators or researchers can develop a program in Turkey in order to increase the self-efficacy beliefs of learners in STEM fields. The effect of the program can be understood by measuring the self-efficacy beliefs of learners with the help of the adapted competency beliefs instrument. Therefore, the instrument is a way to enforce STEM education performance in Turkey.

1.3. Purpose of the study

The purpose of the study is adapting the competency beliefs instrument and validating its' psychometric properties for the use of Turkish researchers and educators. In order to measure self-efficacy beliefs on STEM, STEM Competency

Beliefs instrument was developed by Chen, Cannady, Schunn, and Dorph (2017) in English. In the present study, the original instrument was translated and adapted into Turkish. In addition, the reliability and validity of the adapted instrument were tested. Lastly, the differences in self-efficacy beliefs on STEM among different groups such as gender (male, female), school type (public, private) and job preferences (STEM-related, not STEM-related) were investigated.

CHAPTER 2

LITERATURE REVIEW

This chapter includes four sections. The first section presents the definition of STEM, goals of STEM education, curricular and pedagogical issues related to STEM, and STEM education researches briefly. The second section is about STEM education in Turkey. This section also covers the importance of STEM education for Turkey, changes in national curriculum and actions for STEM education, and STEM education research in Turkey. In the third section, students’ competency beliefs and its significance on STEM education are presented. This section begins with the definition of self-efficacy, and it continues with factors and outcomes of efficacy beliefs for learners based on research findings. In the final section, the test adaptation process will be explained in terms of its necessities, importance, methods and steps.

2.1. Science, Technology, Engineering, and Mathematics education (STEM)

This section is comprised of four parts. The first part includes the definition and importance of STEM. The second part explains the aims of STEM education. The third part presents the curricular and pedagogical issues in STEM education. And the fourth part includes the aims and findings of STEM-related research.

2.1.1. STEM education and its importance

Over the past decade, science, technology, engineering, and mathematics education which is called among educators and in the policy arena as STEM education had national and international attention (NRC, 2014; Kuenzi,2008). Definitions of the four elements in STEM education are explained in the National Research Council as follows: To begin with, science is explained as a body of knowledge and a process of inquiry result in new knowledge. Then, technology is stated as not a discipline but knowledge, processes, and devices that people produced to meet their own needs throughout history. Next, engineering is described as knowledge and problem-solving processes which has constraints such as science, time, money, materials, ergonomics, reparability and manufacturability. Finally, mathematics is regarded as a study of pattern and relationship between quantities, space, and numbers (NRC, 2014).

Components of STEM education differ in terms of their familiarities for K-12 learners. In other words, while K-12 students mostly had courses about science, technology, and mathematics; engineering courses were not common at this level (Moore et al., 2014). Hence, engineering is the newest and the least developed part of STEM education for the K-12 level. Even if there is not a consensus about which content and skills should constitute in engineering education at the K-12 level, there is an important recognition of the significance of engineering design process and concepts such as criteria, optimization, strains, and trade-offs (Moore et al.,2014; NRC, 2014). The components in STEM education listed before as science, technology, and mathematics which are well-known disciplines that are taught isolated manner at primary, middle, and high school levels for years. However, STEM education emphasizes the purposeful integration of the STEM disciplines that the learners are not familiar before (Breiner et al., 2012; Kelley & Knowles, 2016; Tsupros, N., R. Kohler, & J. Hallinen, 2009).

STEM education is substantial for a country in terms of three interconnected aspects: competitiveness in the global market needs for innovation and jobs of future (Atkinson & Mayo, 2010; English, 2016; Johnson, Peters-Burton & Moore, 2016).

First, STEM education is required to keep up with the competitiveness in the global market. At the beginning of the 21st century, STEM fields have gained importance with technological advancement in global markets. Reports, on the other hand, show that the U.S has not enough workforce in engineering fields. According to findings, the U.S has 6%, China 40%, and Singapore 20% of students graduating in engineering each year. Hence, the U.S needed a shift in its workforce compositions to science, technology, engineering, and math to stand in the era competitively. In brief, they needed to teach the desired subjects as science, technology, engineering, and math from a different perspective to enforce their economy. Then, they focused on education projects related to teaching STEM fields and these projects were funded much more than before (Johnson, Peters-Burton & Moore, 2016).

The second reason for STEM education is the need for innovation. STEM education has a significant role in a nation's innovation because it leads to productive employment (Atkinson & Mayo, 2010). According to Atkinson and Mayo’s opinion, science- and technology-based innovation is only possible with a workforce educated in science, technology, engineering, and math content. Science and technology-based innovation provide citizens improved standards of living. It eliminates lower-wage jobs and creates more productive, higher-skilled and better-paid jobs for the economy. It enforces countries in an international market by increasing exports in a competitive environment (Atkinson & Mayo, 2010).

The last reason that accelerates STEM education is the potential jobs of the future. Relying on the prediction, one out of the three jobs will be STEM integrated or strongly related to STEM fields by 2015 (Johnson, Peters-Burton & Moore, 2016).

Therefore, today's students need to receive integrated STEM education as candidates for the future workforce of countries (English, 2016).

In brief, STEM covers knowledge and inquiry, problem-solving processes, patterns and relationships, and producing devices which becomes important for a country's economy. Hence, STEM education needs to be included in the formal education system for future generations and a stronger economy for countries.

2.1.2. Goals of STEM education

Most commonly emphasized STEM goals for students can be grouped into 5 categories namely 21st-century skills, interest and engagement, ability to make connections between disciplines, STEM workforce readiness, and STEM literacy (English, 2016; NRC, 2014; Kuenzi, 2008). Firstly, 21^{st}-century skills involve innovation and critical thinking, communication and collaboration, flexibility, initiatives, and metacognition (NRC,2011). Second, STEM education aims to develop interest and engagement towards STEM subjects (Kuenzi, 2008). Third, a connection between disciplines refers to an interdisciplinary approach in solving problems and is defined as another goal of integrated STEM education (NRC, 2014; Stohlmann, Moore & Roehrig, 2012). Further, workforce readiness as one of the aims of STEM education means the development and improvement of a qualified workforce for STEM fields (English, 2016).

Besides the skills, interest, and workforce readiness in STEM fields, STEM integrated education provides science and technology literate citizen (NRC, 2014). STEM literacy basically is described as an awareness of disciplines, familiarity with concepts and application fluency (Zollman, 2012). Even a citizen who is not interested in STEM-related career needs to gain science and technology literacy in order to be a smart consumer, making thoughtful decisions for policies and understand the world around them (NRC, 2014). According to Bybee (2010), STEM literacy has four dimensions including acquiring, using and applying STEM-related knowledge; understanding features of STEM as a process of inquiry, design, and analysis; engaging in STEM-related issues; realizing of STEM disciplines in real life. One of the reviews on STEM literacy made a meta-review and found that STEM literacy is defined as a positive tendency towards STEM; voluntarily engaging and persisting in STEM areas; appreciation of STEM influence on technology changes; understanding the importance of STEM to solve real-life problems (Cavalcanti, 2017).

To achieve the goals of STEM education, aims, content and teaching methods cooperated together. Therefore, the next part introduces the curricular and pedagogical issues in STEM education comprehensively.

2.1.3. Curricular and pedagogical issues in STEM education

An integrative curriculum is one of the cornerstones to achieving the STEM goals mentioned earlier. While STEM components are taught separately until recently, many real-world problems include more than one disciplines (NRC, 2014). Scientists and engineers work in an interdisciplinary team to develop new products or services in real-life problems. This situation highlighted the need for integrative and connective approaches in STEM education (English, 2016; NRC, 2014). For instance, Next Generation Science Standards which is one of the core curriculums used in science education in the USA emphasized the expectancy from science teachers to teach science and engineering in an integrated form (English, 2016; NRC, 2014). According to NRC, integrated STEM education can take one or several classes, a single course or an entire term, and may be presented in an informal learning setting.

In a project called STEM Road Map (Johnson, Peters-Burton & Moore, 2016) five themes are introduced by 25 science, technology, mathematics, and engineering educators to be integrated into STEM curriculum. These are cause and effect, innovation and progress, sustainable systems, optimizing human experience, and represented world. They explained that students need to understand how and why things happen in order to make a decision as an individual or as a citizen. In addition, students are required to consider what's already known and create value with new perspectives for human benefits. Further, as a human, we live in a sustainable system that needs to be understood by the students that nothing is independent of each other rather all parts are linked to some extent. Learning STEM is a way of thinking logically and systematically for all learners (Johnson, Peters-Burton & Moore, 2016).

As well as the curriculum, it is also significant to learn about pedagogy which refers to how to teach integrated STEM fields in classes. In contrast to common practices, instructional design in STEM is explained as more student-centered, open-ended, problem-based, and experiential (NRC, 2014). Three basic approaches have emphasized the pedagogy of STEM education in literature. These are scientific inquiry, engineering design, and problem-based learning. This kind of approaches provides students an interesting and relevant context that they engage more. While problem-based learning encourages students to be active learners that approach real-life problems with multiple solutions, engineering design process contributes students purposefully act and find the most appropriate solutions for the problems with all constraints. It will be a journey for students that they have an opportunity to plan, create, test, and improve their solutions during STEM classes (Atkinson &

Maya, 2010; Cifuentes & Ozel; 2008; Hacioglu, Yamak & Kavak, 2016; Johnson, Peters-Burton & Moore, 2016; NRC, 2014; Ozel,2008).

In Stem Road map project (Johnson, Peters-Burton & Moore, 2016) 25 leaders in science, technology, mathematics, and engineering argued that the curriculum issues should be innovative, integrated, problem- and project-based which address scientific inquiry and 21st-century skills in a meaningful way. Moreover, they determine 6 elements for an integrated TEM education as listed below (Johnson, Peters-Burton & Moore, 2016, p.5):

-Context needs to be motivating and engaging,

-Engineering design challenge should be included in order to develop students as a problem-solver, creative and higher-order thinker,

-Engineering thinking with test-retest philosophy should allow students to learn from the failure,

-Mathematics and science objectives blended with a problem- and project-based learning environment is needed to be constructed with an addition of other disciplines if appropriate,

-A student-centered approach is important,

-Teamwork and communication abilities are required to be a base for learning (Johnson, Peters-Burton & Moore, 2016, p.5).

Next Generation Science Standards also determine standards for science and engineering practices for K-12 education (NGSS, 2017). They classified the standards in eight parts which are asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, constructing explanation and designing solutions, engaging in argument from evidence and obtaining, evaluating, and communicating information. These standards are stated for each topic in the curriculum for K-12 education (NGSS Lead States, 2017).

As mentioned above, STEM education emphasized the importance of integrated and connected curriculum. Integrated STEM education enhances students' perspectives on real-life problems (Atkinson & Mayo, 2010). Moreover, pedagogical approaches for integrated STEM education provide a student-centered, open-ended learning environment. With the frame of STEM education, students do not need to memorize knowledge because knowledge is available when needed (Atkinson & Mayo, 2010). Rather, the students need to know how to use, manipulate and apply it. Besides the 21st skills including inquiry, design and understanding and applying symbolic language, they remarked the significance of learning for students of the future (Atkinson & Mayo, 2010).

2.1.4. STEM education research

Many researches were conducted to indicate the effectiveness of STEM integrated education focusing on STEM goals as included 21st century skills, STEM interest and career choices (Chittum et al., 2017; Garg, 2015; John et al., 2016; Monterastelli et al. 2011; Maltese & Tai, 2011) and STEM literacy. A tendency to continue with a career in STEM fields is one of the goals of STEM education which heavily studied in the literature (Chittum et al., 2017; Garg, 2015; John et al.,2016; Maltese & Tai, 2011; Monterastelli et al., 2011). Also, pedagogy of STEM education such as engineering design thinking, problem- and project-based learning, and hands-on learning were analyzed in order to observe their effects on the STEM goals (Billiar et al. 2014; English, King & Smeed, 2017; Han, Capraro & Capraro, 2016). Studies mentioned here will be explained in detail respectively.

Firstly, Garg (2015) aimed to expand STEM-related extra-curricular activities in order to develop students' interest and skills for their STEM careers. To achieve the purpose of the study, iSTEM club was established for high school students. Average participation in activities was 50-60 students. The club provided students to create and present their own scientific projects, engaged in entrepreneurship and participating in competitions. Also, they supported the club with inviting guest speakers to enhance their understanding with real-world learning. At the end of the study, considering the members of the club, it is stated that the iSTEM club increased students' interest in STEM-related fields for high school students (Garg, 2015).

In another study, Maltese and Tai (2011) aimed to explore school-based factors affecting students to choose a major degree in STEM fields. They worked with 4.700 U.S students for their study and utilized national exam scores for 8^{th}, $10^{th,}$ and 12^{th}-grade level. Data provided researcher the achievement, attitudes, academic and career plans of the students. They found that students who think that science is useful for their future tendency to earn a degree in STEM areas. A number of science classes attended in high school also positively affects STEM degree. Furthermore, students' interest and ratings of their math and science abilities play a significant positive role in earning STEM degrees later (Maltese & Tai, 2011).

Further, John et al. (2016) were interested in outcomes of STEM education in terms of engagement, capacity and continuity trilogy. They worked with 47 high school students in STEM Academy, but only 20 of them completed signed parental permission. They utilized STEM semantic questionnaire and Students Engagement, capacity and continuity outcome questionnaire in order to understand their interest, career choice, capacity, and continuity in STEM fields. The result of the study showed that students participated in one-year-long STEM intervention engaged with abstract learning and concrete implementation. STEM instruction helped students to comprehend new learning in innovative and creative ways and let them continue these fields as a career option (John et al., 2016).

In another study, Chittum et al. (2017) investigated STEM career intentions of seventh-graders and their persistence in these fields. They worked with 102 students in a Studio STEM after school program. They utilized the inquiry-based approach with the problem-solving procedure about energy conservation in the world. Their theme was "Saving the Animals". The result of the study suggested that after school Studio STEM Program affects participants positively in terms of career choice and disciplines. It is shown that after the program, participants reported science as more interesting and useful and feeling more competent about science abilities. Comparing the result with non-participant students, students who participated in the Studio STEM program were more likely to continue with STEM fields and/or STEM-related careers (Chittum et al., 2017).

Another study is an enrichment program called YESS (Young Engineers and Scientist Seminars) carried out in a Historical Electronics Museum for years in order to provide basic engineering and career opportunities for high schoolers (Monterastelli et al., 2011). During the weekly meetings, they focused on designing, building and testing solutions with engineering integrated health topics. Weekly seminars with engineer young ladies also added to the program for students. In order to understand the differences, researchers used pre- and post- surveys measuring interest, confidence about math and science, and content knowledge about the engineering design process. In conclusion, it is reported that students have increased positive attitudes toward engineering activities. To sum up, extracurricular activities, real-world problems with concrete examples lead students that are engaged in STEM fields to choose STEM fields as career options later (Monterastelli et al. 2011).

STEM pedagogical approaches for integrated STEM education are also studied in the literature. For instance, engineering design is one of the focused issues in integrated STEM education (Billiar et al.2014; English, King & Smeed, 2017). In other words, engineering habit of mind, mainly thinking like an engineer was a part of STEM education.

In their study, English, King, and Smeed (2017) focused on the design process in an integrated STEM approach via earthquake topics with 6th-grade students. The topics of an earthquake are related to math and science subjects as well as technology. It is expected from students to solve problems using design approaches such as problem scoping, idea creation, designing and construction, test and retesting. It was observed that the real-world earthquake problems triggered students to think interconnected factors, engineering techniques, considering the constraints and using appropriate materials (English, King & Smeed, 2017).

Another article, Billiar, Hubelbank, Oliva, and Camesona (2014) have suggestions about the engineering design process as well. It is stated that inquiry-based hands-on activities using the engineering design process engaged students intellectually and actively. Also, they suggested that using the engineering design process in STEM integration lessons makes teacher serving a more productive learning environment for students.

Project-based learning in integrated STEM education is another pedagogical approach investigated Han, Capraro, and Capraro in 2016. Han et al. (2016) investigated the effect of project-based learning STEM education for high-need students. During the study, they worked with 528 Hispanic and at-risk students in

U.S. Math scores of the students between the years of 2008-2010 were gathered to analyze if any differences occur. At the end of the study, project-based learning STEM education framed with student-centered investigation and collaboration increased mathematics achievement for Hispanic students but not for at-risk students.

In conclusion, studies focused on integrated STEM education asserted that STEM education increases 21^{st}-century skills including higher-order thinking skills (Johnson, Peters-Burton & Moore, 2016, p.5). It has also a positive influence on STEM fields as a career option by increasing STEM interest (Chittum et al., 2017; Garg, 2015; Maltese & Tai, 2011). The interdisciplinary approach of STEM education triggers students to think interconnectedly considering constraints and engages students to be more productive and teaches them thinking like an engineer in real-life situations (Billiar et al.2014; English, King & Smeed, 2017).

2.2. STEM education in Turkey

This section is about STEM education in Turkey. It consists of four parts: the importance of STEM education for Turkey is revealed, STEM education at the K-12 level and at the university level are explained, STEM-related research in Turkey are reviewed.

2.2.1. Importance of STEM education for Turkey

STEM education is crucial also for Turkey to have creative, innovative, collaborative and technologically well-prepared students to catch the economic competition in the global market. Like Japan and Korea, Turkey needs changes for economic growth. According to OECD reports, G20 countries are ranked in terms of the development of science, innovation, and the digital revolution with different topics (OECD, 2017).

These topics are machine learning, artificial intelligence, robotization, and scientific documentation. Turkey is ranked 17th for machine learning technologies and is not observed in the top 10 list of artificial intelligence patents and robotization. Also, in scientific documentation, Turkey is ranked 40th in 41 countries (OECD, 2017). Science, engineering and information and communication technologies as mentioned before regarded as direct involvement in technical changes (OECD, 2017). Hence, Turkey needs to enhance STEM-related careers in citizens for a better economy.

In the recent world, jobs are changing rapidly but the skills keep their importance for countries, for Turkey as well. A report emphasized the development of technology and its effect on future jobs in terms of software developments, robots, and automatization (Changing Nature of Work, 2018). People increasingly utilize electronic devices such as smart-phones, tablets, and other portable devices in order to do their daily works. Hence, the number of people who are working in the area of app development and virtual reality, or software engineering, will increase in the future. Robots and automatization are other issues that threaten jobs. According to reports, 47% of the jobs in the U.S are at the risk of automatization (Changing Nature of Work, 2018). It is stated in the report that there are some skills that cannot be replaced by robots. These skills are critical thinking, managing and organizing, and teamwork. These are strongly related to STEM literacy and STEM skills, and important for Turkey to take action about STEM education.

TUSIAD (2019) report emphasizes the importance of STEM education for Turkey's economic growth. STEM fields need to be supported in Turkey in order to achieve the goals of 2023 as a qualified and talented workforce. It is predicted for Turkey that needs for STEM-related jobs in 2016-2023 will be close to 1 million. However, it is argued that 31% of them will not be met (TUSIAD, 2019).

Keeping a competitive position in the global area, technology, innovation and digital transformation regarded as key factors for Turkey as well (TUSIAD, 2019). It is crucial for Turkey to educate its citizens to be creative, productive and lifelong learner throughout the following and adapting the recent technological developments. An education system that contributes productive, innovative, and collaborative learners has an important role in today's world. In this respect, STEM education meets the needs by providing interdisciplinary approach, critical thinking and problem-solving skills, and opportunity to apply theoretical knowledge into practice. STEM supports 21st-century skills including critical thinking, problem-solving, collaborating, leadership, effective communication, creativity, and curiosity (TUSIAD, 2019). It is suggested that in order to maximize Turkey's own potential, STEM education requires to be utilized as a baseline for qualified workforce and skill development that needs for future jobs (TUSIAD, 2019).

2.2.2. STEM curriculum in Turkey

For STEM education at the K-12 level in Turkey, some preliminary steps are taken by the Ministry of Education. Science education curriculum in Turkey was revised very recently (MEB, 2018d). First of all, one of the chapters in science curriculum for 4-8th graders named as "Applied Sciences" was removed with its three objectives. Instead of that chapter, Science, Engineering and Entrepreneurship Practices is added to the curriculum (MEB, 2018d). With this chapter, students are expected to do science, engineering and entrepreneurship projects and present them at the end of the year in the Science Exhibition. On the other hand, it is criticized that the revised curriculum does not provide an effective integrated STEM education (Bahar et al., 2018). For instance, while science, engineering and entrepreneurship concepts are emphasized in the curriculum, there is no link to math in any grade level. Further, the curriculum was criticized from the perspective of practitioners' competency. In other words, for teachers who did not have any STEM education in undergraduate years, the objectives are needed to be clearly defined (Bahar et al., 2018). Briefly, even changes were done related to STEM education, still, there is a need for clarity regarding STEM education in Turkey in terms of its aims, content and pedagogical approaches.

Further investigation of the curriculum in Turkey is about the curriculum of mathematics (MEB, 2018c). Aims of the mathematics curriculum are explained with thirteen items. In a brief list, these are achieving math literacy, understanding the math concepts, reasoning ability while problem solving, explaining the solutions with math terms, explaining the relations between matter and individual, making prediction, gaining positive attitudes towards math, developing ability to being responsible and patient, explaining the relationship between the arts and maths, and giving value towards mathematics (MEB,2018c). It might be said that none of the aims of the mathematics curriculum mention about STEM issues. Moreover, the objectives in the mathematics curriculum are observed and found that technology is suggested to be utilized in the classroom in order to make a concept understandable. Science and engineering, on the other hand, do not appear in the mathematics curriculum. Therefore, it is concluded that the mathematics curriculum does not include STEM issues.

Another change of the curriculum in Turkey is the curriculum of an elective course called Applied Science (*Uygulamalı Bilimler*) (MEB, 2018b). First, as its aims are strongly related to science, technology, engineering and entrepreneurship (MEB, 2018b, p.7-8):

“-Taking responsibilities about life problems and providing science process skills with life and engineering design skills in order to solve the problems

-Developing a sense of awareness of recent science and technological innovations

-Developing career awareness and entrepreneurship skills”.

Second, engineering and design skills are introduced as one of the aims (MEB, 2018b). According to the definition of the curriculum, engineering and design skills involve the integration of science, technology, and engineering concepts and provide interdisciplinary perspectives towards problems. Also, it is expected that students who are equipped with the skills are able to create invention and innovation with their knowledge. Moreover, they are expected to add value to their products via developing strategies. At the end of the part, it is declared that the program focusses on the nature of science and science process skills and provide a frame for life and engineering design skills. Hence, the expectation of the program involves providing the similarities and differences between disciplines such as science-technology-engineering and mathematics (MEB, 2018b). Third, 21st-century skills are defined as one of the goals of Applied Science. It is stated that activities selected for the course based on the science curriculum, but the interdisciplinary approach needs to be applied (MEB, 2018b). At the end of the program, a list of competencies was described. Many objectives indicate science- technology- engineering and entrepreneurship relationships. These objectives are listed below (MEB, 2018b, p.10-11):

- “Students realize that creativity and imagination are important to development for engineering and technology.
- Students explain the relationship between science, technology, engineering, and mathematics.
- Students utilize the relationship between disciplines.

- Students utilize the engineering design process and entrepreneurship to develop a product”

In conclusion, it is observed that the objectives of the elective course named Applied Science emphasize STEM.

Corlu Capraro and Capraro (2014) emphasized that educators who are well educated with STEM are one of the core elements for a nation to raise an innovative generation. Hence, Colakoglu and Gokben (2017) investigated STEM-related activities in Education faculties. To achieve the goal of the study, a 12-item survey with one open-ended question was submitted to 92 deans of education faculties in Turkey. 61 of them completed the survey. The items were related to whether or not STEM courses, laboratories, institutions, EU projects, master and doctorate programs exist at the universities. As a conclusion of the study, Colakoglu and Gokben (2017) reported that 26% of the universities have a STEM-related course(s), only 21% of them have STEM laboratories, 8% of them have a STEM institution, 13% of them have STEM-related EU projects, 16% of them have a defined STEM policy and none of the universities have a master or doctorate program about STEM education. Findings showed that even though interest and awareness about STEM education were high, there is still a need for more action to improve the area (Colakoglu & Gokben, 2017). Moreover, it is argued that there is still not any program yet to educate pre-service teachers appropriately for STEM education (Colakoglu & Gokben, 2017).

There is also a suggestion about how to teach STEM education in Turkey. Even though STEM education is not a part of an undergraduate teaching program, it is significant for science and math teacher candidates to be equipped with integrated STEM education appropriately. Ozel (2008) focused on problem-based learning for STEM education. He explained different aspects of problem-based learning in detail.

He argues that everyone can apply problem-based learning with different roles as administrators, teachers or partners. It is mentioned that administrators need to support teachers to implement problem-based learning successfully. Another role is providing rich resources for teachers also. Teachers, on the other hand, are required to be a facilitator in the class and coaches of the learning process of students. Problem-based learning can be implemented everywhere from kindergarten to universities which lead students as lifelong learners. For the question of when to use problem-based learning, it is reported that each moment that students develop personal investment and real-world problems which educational sound emerges. Researches also support using technology with project-based learning and provide some examples that can contribute class activities for teachers (Cifuentes & Ozel, 2008)

Changes in national curriculum and suggestions about the pedagogy of STEM can be regarded as important steps for Turkey. Next part explains the researches about STEM education conducted in Turkey.

2.2.3. STEM education research in Turkey

The STEM education research in Turkey consists of the topics related to both teachers as well as students. Cognitive structure and perception of the teachers about STEM education were investigated (Aslan-Tutak, Akaygün & Tezsezen, 2017; Hacioglu, Yamak & Kavak, 2016). Also, STEM pedagogy as a teacher development program was explored (Hacioglu, Yamak & Kavak,, 2016). From the students' point of view, interest level, career choices, and their perception about STEM fields were studied (Baran, Canbazoglu-Bilici, Mesutoglu & Ocak, 2015; Gülhan & Şahin, 2016;

Sahin, Ayar & Adıgüzel, 2014; Yerdelen, Kahraman & Taş, 2016). The related studies will be explained below.

Firstly, Hacıoglu, Yamak and Kavak (2016) searched for the cognitive structures of pre-service teachers studying at the Primary Education Department in order to understand what the teachers have in their minds regarding STEM. They used the Word Association Test and a semi-structured interview with 192 pre-service teachers. Findings showed that pre-service teachers have a weak understanding of the relationship between the STEM disciplines and they were unable to use their knowledge in other contexts where other disciplines needed to be connected (Hacioglu, Yamak & Kavak, 2016).

Another preliminary research was conducted to understand the perspectives of pre-service teachers towards STEM education. Aslan-Tutak, Akaygün, and Tezsezen (2017) designed and applied a Collaborative STEM Education module. They worked with 48 pre-service teachers to analyze differences about the definitions and pedagogy of STEM education via STEM Awareness Survey applying before and after the module. According to the findings, understandings of the participants about integrated STEM education changed dramatically. After the program, pre-service teachers emphasized a project-based, integrated STEM education approach with activities which is connected with different disciplines. Mathematics and science integrated curriculum developed by a university has a positive effect on mathematics and science teacher's attitudes. Such a program makes pre-service teachers ready to utilize STEM education by adapting to the Ministry of National Education objectives (Corlu, 2012). All of the studies informed us about the importance of teacher training program with regards to STEM education in Turkey (Aslan-Tutak, Akaygün & Tezsezen, 2017).

Engineering design-based learning is also one of the teaching methods in STEM education. To understand the effect of the engineering design-based learning, Hacioglu, Yamak, and Kavak (2016) studied with 192 pre-service science teachers via inspiring practices which can be applied in schools. They utilized interviews with teachers to collect the data. After the workshops, the attended teachers expressed their opinion about engineering design-based learning in a positive manner and added that they would use it in their classes. Teachers listed their reasons to be positive about the idea as follows: it improves their occupational skills, the method is engaging and interesting, it helps students to improve their creative thinking, collaborative working, and inquiring skills. Moreover, they believed that such progress will enhance students' knowledge of concepts. However, they also stated the disadvantages of engineering design-based learning. They felt anxious about applying what they learned there because they felt not enough to integrate engineering ideas into real-world problems. Also, they added that such activities lead to classroom management problems for teachers. Another perspective is financial problems to do such activities in class even though they worked with recycled materials throughout the workshops. The study finalized the research with suggestions that teachers are needed to educate with in-service training and supported with projects and researches (Hacioglu, Yamak & Kavak, 2016).

In the informal learning environment, gifted education and the history of science are also needed to adapt the change and include integrated STEM education to their circumstances. Research conducted by Ayar (2015) investigated STEM education in an informal learning environment in a metropolitan city in Turkey. It was a robotics summer camp for 30 students at the high school level. Observation, field notes, and interviews were used to gather data for the study. The camp differed from school in terms of goal, practice, and social structure. Students were required to gain engineering activities with a hands-on minds-on approach, and they worked in pairs collaboratively. It is claimed that students engaged in engineering activities and felt more competent via summer camp. Besides that, engineering as a career choice was increased after the camp (Ayar, 2015).

There are many pieces of research which were conducted to understand students' perceptions, attitudes, and interests towards career options in STEM fields. The influence of STEM education on STEM literacy and 21st-century skills for students was also investigated (Baran, Canbazoglu-Bilici, Mesutoglu & Ocak, 2015; Gülhan & Şahin, 2016; Sahin, Ayar & Adıgüzel, 2014; Yerdelen, Kahraman & Taş, 2016). The researches were reported in detail below.

Students' interest level towards STEM fields is significant to determine future career choices. Yerdelen, Kahraman, and Taş (2016) investigated STEM career interest of low socio-economic status middle school students. The effect of demographic variables including gender and grade level on STEM career choices was analyzed. 263 students coming from 5th, 6th, and 8th-grade level were attended to surveys. Instruments used during the study were the STEM semantic survey for career interest, student attitudes toward STEM scale and STEM career interest scale. Findings suggested that students regarded STEM careers as interesting, exciting, fascinating and appealing. Grade levels and gender was not a predictor of the result. Another important result is the majority of students prefer a life science career for their future. Being a medical doctor is very popular in Turkey, therefore this could affect students' perception about their career-related opinions (Yerdelen, Kahraman & Taş, 2016).

Another study conducted by Gülhan and Şahin (2016) searched for the influence of STEM integrated approach towards STEM attitude and STEM perceptions of the students. They worked with 55 students of 5th grade for 12 weeks. To assess the differences if any occurs, the participants were separated into two as control and experiment groupsl randomly. Control group studied based on national science curriculum applied in Turkey. Experiment group, on the other hand, studied the national science curriculum and STEM activities. It is found that students in the experiment group obtained higher scores in STEM perception test. In detail, it is argued that engineering, technology, and career choices were the parts that were significantly different from the control group. For the attitude test, engineering, science, and technology were the components in the scale that observed significantly different from control groups positively. Mathematics, on the other hand, was not affected by any groups. Both in perception and attitude tests, engineering and technology were increased in experiment groups which supports that STEM activities have a positive impact on students' attitudes and perceptions about STEM fields (Gülhan & Şahin, 2016).

In another study, Sahin, Ayar, and Adıgüzel (2014) searched for outcomes of integrated STEM education in an after-school program. They looked 4 points during the study including collaborative learning, the popularity of after school program, interest in STEM fields and 21st-century skills. They used semi-structured interviews and field notes as qualitative data. Participants consisted of 146 students from 4th to 12th grades. The open-ended, real-world and uncertain problems were provided for the participants during the programs. It is concluded that students engaged with collaborative group works and they learned from each other. After school program may be regarded as a tool to promote STEM literacy because students who participated in the activities enhance problem-solving skills encountered in daily life. They learn to design, model and establish solutions for problems with minimum cost and maximum efficiency. Such activities have an influence on students and lead them to attempt a STEM-related career in the future (Sahin, Ayar and Adıgüzel, 2014).

Further research by Baran et. al, (2015) implemented an integrated STEM education in an out of school environment with 40 6^{th} graders living in a disadvantaged urban city in Turkey. Students participated in STEM activities for 13 weeks which takes 40 hours. Interviews were used to collect data for the study. The study showed that out of school programs which are hands-on, design-based, collaborative and inquiry-oriented were effective to engage students in design and engineering practices. It helped students' interest and knowledge towards STEM fields (Baran et. al, 2015).

To sum up, the studies about STEM education conducted in Turkey emphasized that an integrated STEM approach has a positive influence on students' perceptions towards STEM fields and increases their career choices.

2.3. STEM self-efficacy beliefs

Achievement and academic performance are important for education. One of the factors that influence the performance in a given domain is self-efficacy (Bandura, 1999; Bouffard-Bouchard, Parent & Larivee, 1991). Self-efficacy is defined as the capability of an individual's point of view for himself/herself to perform at a level of proficiency (Bandura, 1999). Self-efficacy is also interchangeably used perceived self-competence (Zimmerman, 1995).

There are some specific characters of self-efficient people which result in better academic performance. One of them is, self-efficient people are resilient that makes these people balanced against adversity. Also, they are solution-oriented people who trust in their capabilities maximize their efforts and try to find new solutions to problems they encounter. Another point is their perceptions of failures that differ them from others. Whereas people who have low efficacy regard failures as inability, a high self-efficient individual attributes failures to insufficient effort, weak strategies or conditions (Bandura, 1999). These characteristics features influence their academic performance positively.

Regarding the studies, self-efficacy affects academic performance in different ways. First, self-efficient people are able to work harder and longer. It is stated that students who trust themselves have a chance to get better academic performance because they work longer and harder and seem less anxious (Pajares, 1997). Second, they have better self-regulation because self-efficacy is a basis for self-regulation (Bandura, 1999). Next, students who have higher self-efficacy are more active in control of time and better at task focus (Bouffard-Bouchard, Parent & Larivee, 1991). A final way is a positive relationship between the interest and self-efficacy (Hidi & Ainley, 2008). The more the students believe themselves, the more they are interested in their subjects. Thus, educators are required to help learners to experience better feelings and improve their beliefs about themselves. It helps students continue to work on or reengage with activities, ideas, objects so on, and to increase knowledge and a stored value (Hidi & Ainley, 2008). Common behaviors observed in self-efficient people positively enforce their academic performance.

It is also fundamental to find out what contributes to the efficacy of learners. Studies show that four factors may have an impact on perceived self-efficacy of an individual. One of the factors is that feedback given to students affects their confidence and performance (Bouffard-Bouchard, 1990). Students who are positively judged received more correct answers than those who judged negatively. The other factor is an expectation from or of parent and teacher influence of the students' self-efficacy (Bouffard-Bouchard, 1990). The study shows that expectation of self-efficacy which contains motivational component influences on when and how long a person will keep his/her continued on behavior for the desired outcome. Another factor is stated as achievement goals of the students (Bouffard-Bouchard, 1990). While high self-efficient students have higher achievement goals, low self-efficient students have lower ones (Bouffard-Bouchard, 1990). A final factor is early experiences (Lent & Lopez, 1991). A study demonstrates that early experiences for a certain behavior or performance result in self-efficacy; regarding oneself as competent and tendency to enhance interest in that area; then, such interest trigger for further experiences, and influence career choices (Lent & Lopez, 1991). It was also found that optional science experiences that depend on the students' preferences were associated with competency beliefs (Vincent-Ruz & Schuun, 2017).

In conjunction with these findings, self-efficacy is an important determinant for academic performance and career choices in STEM education (Kanny, Sax & Riggers-Piehl, 2014). One study used a meta-narrative systematic review of the literature to address the issue as the gender gap in STEM fields. In order to analyze the factors that have an influence on the gender gap in STEM fields, they grouped them into five parts: individual background, structural barriers in education, psychological factors, values and preferences, family influences and expectations, perceptions of STEM fields. Individual backgrounds refer to socio-economic status and race. Structural barriers are regarded as schools, curriculums, pedagogy, peer interactions, achievement in standardized tests. Psychological factors relate to self-confidence, self-concept, personal orientation and sense of belongingness in STEM fields. Family expectation is linked to the individuation and separation process of females. Also, maternal identity was a factor considered in the family expectation group. The research asserted that self-confidence or self-concept is the most oft-cited explanation for the gender gap in STEM fields (Kanny, Sax & Riggers-Piehl,2014).

A further example, Green and Sanderson (2018) designed a longitudinal study between 2003-2009 and analyzed the factors that have an impact on STEM success. Findings indicated that ability, consistently mentioned in the literature, had an impact on STEM persistence and attainment. Also, there seemed to an inclination that math ability leads to more STEM majors for students. Self-efficacy, on the one hand, showed a large impact on STEM persistence (Green & Sanderson, 2018).

Self-efficacy becomes an important factor affecting differences between genders. The study conducted by Telhed, Backström, and Björklund (2016) focused on women's lower interest in STEM fields. They worked with 1327 Swedish high school students and utilized competency beliefs and social belongingness expectations tests. Findings asserted that differences between male and female students were strongly related with lower self-efficacy of females for STEM careers. They emphasized that to lessen the gender segregations in STEM fields, it is needed to give importance to self-efficacy and social belongingness. One of the ways for increasing women in the area is decreasing the effect of competency beliefs (Telhed, Backström & Björklund, 2016). Besides, Hackett and Betz (1982) conducted a study search for the differences in mathematics self-expectation between male and females. They found that males had stronger self-efficacy expectations than female did. It is concluded that self-efficacy expectations of mathematics were a crucial indicator of a science-based college degree. Hence, beliefs about capabilities function as an important role that influences science or non-science related majors and careers (Hackett & Betz, 1982).

There are underlying reasons behind the self-efficacy differences between male and female students in STEM education. Three dimensions appear to explain the reasons for the gender gap in STEM fields. First one is related to role models that students are exposed to. A study showed that even controlling the other variables including ability and prior knowledge, it was seen that not the actual competencies but beliefs about competencies influence how much a student learn (Vincent-Ruz & Schuun, 2017). While it is equally predictive for 6th graders in both genders, it is distinctive in 8th graders for girls. From the points of girls who encountered less role model for science-related jobs, believed they are at risk. Hence, competency beliefs matter more for girls (Vincent-Ruz & Schuun, 2017). The second one is different perspectives to develop self-efficacy for males and females. A study collected narrative data about men's personal stories to select STEM career and compared the data with women's criteria (Zeldin, Britner & Pajares, 2006). According to findings, men and women have different ways to develop self-efficacy in a STEM-related career. While men depend on their own achievements and successes, women interpret themselves heavily on vicarious experiences and social persuasions. Vicarious experience defined as observing others' successes and failures and judging about own capabilities. It is closely related to the role model. Social or verbal persuasions, on the one hand, defined as ideas and messages from others for an individual to accomplish a task or not. Hence, women for STEM-related career are more vulnerable because it is a male-dominated area and they cannot believe that they can accomplish (Zeldin, Britner & Pajares, 2006). The third one is math efficacy of the students. According to the study, low math self-concept is regarded as an important reason for women's underrepresentation in STEM fields (Sax et al., 2016). Hence, it is questioned that how math self-concept impacts male and female career choices over the past four decades. It is seen with the result of the study that women's self-concept about math were lower relative to men. Also, the result shows that lower math self-concept leads to reduce the number of women in STEM fields. They suggested that math self-concept is a matter for women and needed to be increased (Sax et al., 2016).

There is evidence that some approaches increase students' self-efficacy in STEM fields. One of the approaches depends on the instructional method which is integrated STEM education.

In a study, research demonstrates that informal science experiences with field trips and culturally relevant activities have a positive influence on students' beliefs about STEM. The study conducted by Stevens, Andrade, and Page (2016) focused on females and minorities in their study. They tried to engage 3^{rd} -8^{th} graders in STEM learning by providing in-school mentoring and out of school informal science education experiences with field trips. It is found that the program increased STEM interest in females and a tendency to choose STEM-related careers as a result of participants' science beliefs. Additionally, culturally relevant activities lead to increase self-efficacy for the participants (Stevens, Andrade & Page, 2016).

Different assessment tools for STEM and self-efficacy are founded in literature. Milner, Horan, and Tracey (2014) developed 4 different assessment for STEM interest and self-efficacy which can be listed as The STEM Career Interest Test, The STEM Career Self Efficacy Test, The STEM Occupational Interest Test, The STEM Occupational Self Efficacy Test. They found that there is a consistency between interest and efficacy. Participants who stated high levels of interest in STEM fields career showed a high level of efficacy in those areas. However, there is a need for a tool that assesses students' beliefs about their capabilities in STEM fields.

In the present study, it is aimed at to adapt an assessment tool named as STEM Competency Beliefs Instrument into the Turkish version. It is a preliminary step for the research area that connects the self-efficacy with STEM education.

2.4. Adaptation of an instrument

This section presents the process of test adaptation into another language and culture.

2.4.1. Definitions of test adaptation

Methodology in translation and adaptation of an instrument has enhanced rapidly in 25 years. Reasons behind this rapid development are based on four issues. The reasons are interest in cross-cultural psychology (Vijver & Hambleton, 1996), international comparative studies in education, worldwide exams and fairness in testing for language preferences (ITC, 2017; Hambleton, Merenda & Spielberger, 2012).

Definitions and differences between translation and adaptation processes need to be explained clearly. Test adaptation is a term that is more preferred and commonly used because it is broader and more reflective term compared to the test translation (Hambleton, Merenda & Spielberger, 2012; ITC, 2017). Activities applied through test adaptation involve deciding whether the same construct occurs in different languages, determining translators, deciding accommodations, adapting the tests and checking for equivalence. On the other hand, test translation is only one of the steps that happen in adaptation. The step is translating a test from one language to another. However, even in one step, it is not a translation solely but an adaptation process. While translating a test to another language, it requires thinking deeply in terms of cultural, psychological, and linguistic issues (Hambleton, Merenda & Spielberger, 2012). In brief, translation, and adaptation refer to different meanings and the adaptation is a more comprehensive term than translation.

To achieve the adaptation process of a test, standards are determined with the collaboration of the American Psychology Association, The American Educational Research Association, and National Council on Measurement in Education. It is possible to observe errors between two different versions of tests. Errors in adaptation depend on cultural differences, technical issues and interpretation of results. In order to minimize the errors between an original test and adapted one, three basic standards were mentioned in the guideline (NCME & AERA, 2014). These standards are listed below:

> Standard 6.2. When a test user makes a substantial change in test format, mode of administration, instructions, language, or content, the user should revalidate the use of the test for the changed conditions or have a rationale supporting the claim that additional validation is not necessary or possible.
>
> Standard 13.4. When a test is translated from one language or dialect to another, its reliability and validity for the uses intended in the linguistic groups to be tested should be established.
>
> Standard 13.6. When it is intended that the two versions of dual-language tests be comparable, evidence of test comparability should be reported.

In brief, there are many details in the test adaptation process from cultural issues to the sentence's structure. Within the difficulties, it provides a cross-cultural understanding of psychological and educational concepts.

2.4.2. Steps of test adaptation

Adaptation of a test consists of different steps and methods to follow. This section informs of the general steps and various methods utilized in the test adaptation process.

Vijver and Hambleton (1996) listed steps for the test adaptation process. The guideline has 22 steps. These steps help a researcher by saying what is critical throughout the adaptation process. Some of the critical steps from the list of Vijver and Hambleton (1996, p.11-25) study were below;

1. Minimizing the effect of cultural differences
2. Utilizing familiar items for an intended population
3. Utilizing the appropriate statistical techniques to measure the equivalence of the instrument
4. After the translation and adaptation process, documentation is needed to show the equivalence
5. Providing specific information about socio-cultural and ecological context of populations that might affect on interpretation of results.

International Test Commission (2017) published an adaptation guideline that describes steps which are classified as before adaptation, in progress and after adaptation. According to the guideline, before the adaptation, three steps are suggested for experts. These are listed as obtaining permission from test developers, evaluating the similarities between cultures and minimizing the cultural and linguistic differences. In progress part of the adaptation, five steps are emphasized. These are sequenced as ensuring the minimal cultural differences, using appropriate design method to maximize suitability, providing evidence that the test is the same for intended populations, providing evidence for the structure of the test, collecting a pilot data to complete necessary revisions. The last part, after the adaptation process, four steps are needed to be completed. These are determining the sufficient size of the sample, providing statistical evidence for construct equivalence, providing evidence for reliability and validity analysis and using appropriate data analysis procedure (ITC, 2017). Besides the steps mentioned here, scoring and documentation are emphasized in the guideline.

Besides, proceeding with the methodology of the adaptation process, two popular design methods for test adaptation appear in the literature as forward translation and backward translation which are explained in detail in the next part.

2.4.2.1. Forward and backward translation

To begin with forward translation, the definition, process, advantages, and disadvantages of the method are stated. The forward translation is a process that one or more translators adapt the test from the source language to target language (Hambleton, Merenda & Spielberger, 2012). Then, preferably another translator observes both the source and target test and decide the equivalence if emerges. After the equivalence, revisions and smooth editing are completed on the target test. Forward translation has advantages to some extent because it is kind of "think aloud" process that allows making judgments directly on the test. Disadvantages of the method are depending heavily on translators' inference that might be misleading.

Backward translation is another method utilized for test adaptation. Backward translation has three main processes in itself (Hambleton, Merenda & Spielberger, 2012). Firstly, a test is translated from the source language to target language by determined translators. Then, different translators translate the test from target language back to the source language. Finally, these two forms of the test as source language and back-translated version are compared for equivalence (Hambleton, Merenda & Spielberger, 2012). The backward translation allows the researcher to compare two forms in a more objective level. The drawback of the back-translation method is that translation could be poor, but comparisons look still fine which is misleading again.

Maneesriwongul and Dixon (2004) conducted a meta-analysis for adaptation studies. They observed six different categories for adaptation methods and testing. These are a forward-only translation, forward-only translation with testing, back-translation, back-translation with monolingual testing, back-translation with bilingual testing and back-translation with both monolingual and bilingual testing. They stated that there is not a standard way for the translation process in the literature. Variety of methods and testing approaches are utilized in these studies (Maneesriwongul & Dixon, 2004).

In conclusion, there are important criteria for the adaptation process of a test ranging from determining translators to smooth editing. Also, there are well-known methods to adapt a test including forward and backward translation which have both advantages and disadvantages. Further, there are many ways to test the equivalence of the adapted instrument among monolinguals to bilinguals. All suggestions can be utilized appropriately throughout the adaptation process in order to construct a valid cross-cultural instrument.

2.4.3. Critical issues in test adaptation

Errors and invalidity might occur when adapting a test from one language to another. Hambleton, Merenda, and Spielberger (2012) stated the sources of errors with three main issues including cultural/language differences, technical issues such as design and methods, and the interpretation of results.

Firstly, cultural/language differences may lead to errors in adaptation. It involves construct equivalence, administration of the test, item formats, and the influence of speed on examinee performance (Hambleton, Merenda & Spielberger, 2012). One of the factors, construct equivalence, refers to the equivalence of concepts and functions in the cross-cultural area. Another factor, administration of the test, means the clarity of directions in a test that minimizes verbal support. Further, item formats are related to how the items presented to the intended people. A final factor is a speediness which means spending time to complete a test (Hambleton, Merenda & Spielberger, 2012).

Secondly, the issues that might cause errors in adaptation are technical factors (Hambleton, Merenda & Spielberger, 2012). Five factors that have an effect on adaptation errors are the test itself, translators, the translation process, judgmental designs for adapting tests, and data collection designs and data analysis for establishing equivalence. To begin with the test itself, each item, sentences, structure, and formats should be taken into consideration for a better-adapted test. Moreover, translators need to be competent and it is better to work with more than one translator. Also, frequencies, expressions, and de-centration need to be similar to both languages. Judgmental designs for test adaptation have different types as forward and backward. They have both advantages and disadvantages explained previously in detail. Data is the last issue in technical factors. Collection of data can be done in three different ways. These are listed as giving source and target test to bilingual people, giving the source and back-translated version of the test to the source language monolinguals, and giving the source to the source language monolinguals and target test to the target monolinguals. Throughout the process, the sample size needs to be enough (Hambleton, Merenda & Spielberger, 2012).

The last one is related to the interpretation of the results. While observing the results, the focus should be on comparisons between both languages sample in order to understand the similarities and differences (Hambleton, Merenda & Spielberger, 2012). To make comparisons between the different languages, other factors are needed to be considered such as motivation, socio-political issues or curricula.

CHAPTER 3

METHOD

The purpose of the present study is to adapt a valid and reliable Turkish version of the STEM Competency Beliefs Instrument. The aim of the instrument is to assess middle school students' perceived STEM self-efficacy. This chapter explains the process in five parts. These parts are information about the original instrument, an adaptation of the instrument, pilot study, main study, and data analysis. In the first part, the original instrument is presented in detail. Then in the second part, the adaptation process of the instrument is explained. In the third part, the details of the pilot study procedure are presented. In the fourth part, the main study is explained. In the final part, the statistical analysis and findings of the instrument are reported.

3.1. Original instrument

The instrument is originally developed in English and named as STEM Competency Beliefs. It depends on the social cognitive theory (Bandura, 1986). The aim of the instrument is to assess students' perceived self-efficacy beliefs about STEM-related performance and skills.

The instrument was developed by Chen, Cannady, Shun, and Dorph (2017) for 10-14-year-old learners. It involves 12 statements. Some of the survey statements were listed below as exemplary items.

I can do math problems I get in the class.

I am the technology expert in the house.

I can understand science in books for adults.

I think; I'm very good at figuring out things that don't work.

Each statement is answered by 4-point Likert Scale. In original version, the options for all statements in the survey were “yes!, yes, no and no!”. However, it was argued in the adaption team that these were not clear for Turkish children. Hence, while adapting the items into Turkish, these options were not directly translated. Most of the options were adapted in Turkish version as “definitely agree – *kesinlikle katılıyorum*, agree – *katılıyorum*, definitely disagree – *kesinlikle katılmıyorum*, disagree – *katılmıyorum*”. Moreover, it was used differently for some options in order to make the statement clearer. For instance, options in Item 3 are different in Turkish instrument as written below:

3.Fen ve teknoloji kulübünde kendi projemi yapıyor olsaydım, bu proje…….. bir proje olurdu.			
Çok iyi	İyi	Orta	Zayıf

In the original STEM Competency Beliefs instrument, unidimensional assumption analysis, item analysis, PCM model-level, and item-level fit statistics were conducted with a sample of 205 middle school students. The findings demonstrated that the reliability of the scale was acceptable with Cronbach’s alpha equal to 0.83. The result of all CFA model fit indicators showed that the data had a good fit to the one-factor structure with Confirmatory Fit Index [CFI]=0.974; Tucker-Lewis Index [TLI] = 0.969; Root Mean Square of Approximation [RMSEA] = 0.052.

3.2. Adaptation of the instrument

For test adaptation, there are some preconditions including asking permission from the test developers and evaluating cultural similarities and differences. The permission was granted for the adaptation of STEM Competency Beliefs instrument into the Turkish version (M. Cannady, personal communication, November 12, 2018). To achieve a valid adaptation of Turkish version of the STEM Competency Beliefs instrument, three steps were followed namely forward translation, backward translation, and final version editing. These steps were explained in detail in the following parts. Then, a pilot study was conducted to evaluate the clarity of the items in the pilot instrument. Finally, the main study was conducted to collect data in order to evaluate the reliability and validity analysis of the adapted instrument.

3.2.1. Forward translation

As the first step of the forward translation, two Turkish translators were determined in order to translate the instrument from English version to Turkish. The researcher was also included in the translation process. Three translators had different occupations including an English teacher, an English interpreter and a researcher in science education. The English teacher had 5 years of experience in public schools and the interpreter had 7 years of experience in a translation office. The translators lived in different districts in Turkey and they were native Turkish speakers. The researcher is a science teacher and 2 years experienced in the science center as an education coordinator.

For the forward translation, each translator translated the instrument separately. Then, the translated forms of the instrument were collected in an Excel document in order to select the best one. An associate professor in science education, an assistant professor in assessment and evaluation and the researcher worked as a team and compared the translations. The team discussed the terms especially related to STEM education in detail. For instance, the word “after school science club” was argued in the team a lot because “after school” is not a commonly used term in

Turkey. It was found that students had “science and technology clubs” with the same meaning. These students’ clubs were mentioned in the National Education Social Activities Program Students’ Club (MEB, 2009). Hence, “science and technology clubs” was used in the forward translation in order to make it familiar for students. The other argued one was the sentence pattern as “I think I’m very good at…” in the instrument. These sentences having the patterns were not translated as they have seen, but they translated as how we speak in Turkey. At the end of the discussion on the first draft of the translation, a consensus form was determined, and the instrument was ready to backward translation.

3.2.2. Backward translation

For the backward translation, two different translators were added to the process. One of them is working in a private school as an English teacher. She was a bilingual person who lived in England for 25 years. The other one was an author and she is a bilingual American. Both have lived in İstanbul recently.

The first translation form of the instrument was sent to both translators in order to translate the Turkish form back to the English. The translations again were written in an Excel form to compare. The team who are in the forward translation phase, analyzed the forms in order to get a consensus form. An important criterion for the consensus form is similarities between the original form of the instrument with back-translated form. Then finally, the team determined a consensus for back-translated instrument.

3.2.3. Adapted version of the instrument

As a final step, one linguistic expert was included in the adaptation process. She has 8 years of experience as an English teacher in different universities for prep students and is a doctorate student in learning sciences program during the study.

For that part, the back-translated version of the instrument was compared with the original one. The linguistic expert checked for the equivalence of the instrument. She commented on item 4 and made a change on it. Also, she questioned the sentence pattern in 7^{th}, 8^{th}, and 9^{th} items.

After that, the final version of the instrument was completed and again reviewed by associate professor, assistant professor, and researcher. Then, the instrument was ready for the pilot study.

3.3. Pilot study

In the pilot study, it was aimed to evaluate the clarity of the items from students' perspectives. In demographic information part, questions are asked to students such as career choices, school type, grade and scientific hobbies. Sample and pilot instrument of the study are mentioned in detail in the following parts.

3.3.1 Sample for the pilot study

A total of 77 students from different backgrounds participated in the pilot study in order to test the psychometric properties of the instrument. The students were visitors to the science center in Turkey. They attended a workshop in the science center, then they were included in the survey.

The participants were 32 male and 45 female students as seen in Table 1. Seven of the students were from private schools and 70 of them were from public school. For the grade level, most of the participants were 4th graders. 5 students were 7th and 8th graders, 20 students were 6th graders and 17 students were 5th graders.

Table 1. Pilot Study Participants

	Public School		Private School	
	Female N(%)	Male N(%)	Female N(%)	Male N(%)
4th grade	13 (16.9%)	17 (22.1%)	0	0
5th grade	11 (14.3%)	5 (6.5%)	0	1 (1.3%)
6th grade	17 (22.1%)	2 (2.6%)	0	1 (1.3%)
7th grade	1 (1.3%)	0	1 (1.3%)	3 (3.9%)
8th grade	2 (2.6%)	2 (2.6%)	0	1 (1.3%)

For the study, they were given 10-12 minutes to complete the instrument. Teachers in the workshop and the researcher were there to make them comfortable to finish the survey.

3.3.2 Instrument for the pilot study

In order to understand the clarity and fluency of the translated instrument, 2 more questions added at the end of the survey. These questions were "Is there any question that you struggle to understand?", "if yes, which question(s) were they?". Answers were used to determine if the instrument needs any changes or improvement before finalizing the Turkish version.

Except for one child from 4th grade, all the participants wrote that there was not a question that she/he had a difficulty to understand. One child, on the other hand, expressed that item 2 was difficult for her/him because the word "website" (website) was not familiar to him. Then, the word "website" changed as "internet sitesi" for the main study.

3.4. Main study

After the pilot study with feedback from the students, the data was collected to analyze the reliability and validity of the data collected by Turkish version of the instrument.

3.4.1 Sample for the main study

Participants of the main study were 330 students coming from different schools as visitors to the science center in Turkey. All the participants received the information and consent form as seen in Appendix A. Before the instrument, participants answered the personal information questionnaire as seen in Appendix B. Using the personal information questionnaires, Table 2 shows that the gender percentages of the students regarded as a balanced, consisting of 159 females and 171 males, with 48.2% and 51.8% respectively. Also, students who participated to the study were coming from different school types as public schools (n=305) and private school (n= 25), and their percentage was calculated as 92.4% and 7.6% in total as seen in Table 2. The percentage of the school type of students was also quite consistent with the Turkish Ministry of Education Statistics of 2018. It was reported that 6.4% of the students attended private middle schools in Turkey (MEB, 2018a).

Table 2. Main Study Participants

	Public School		Private School	
	Female N(%)	Male N(%)	Female N(%)	Male N(%)
5th grade	46 (13.9%)	54 (16.4%)	2 (0.6%)	14 (4.2%)
6th grade	1 (0.3%)	7 (2.1%)	2 (0.6%)	7 (2.1%)
7th grade	82 (24.8%)	72 (21.8%)	0	0
8th grade	26 (7.9%)	17 (5.1%)	0	0

As applied in the original scale of the STEM Competency Belief's test, the study was conducted with elementary school students in the age of 10-14. The sample was ranged from 5th graders to 8th graders. Most of the students were 7th graders involved in the study as seen in Table 2. While 5th graders were 116 students, 8th graders were 43 and 6th graders which has the least participants, were 17 students. The distribution depended on the visitors to the science center.

3.4.2 Instrument for the main study

The final form of the instrument was changed with the feedback gathered from the pilot study. One feedback related to the word "website" was considered too difficult to understand for students. Intensive working on the instrument throughout the adaptation process resulted in a good pilot instrument which was used substantially in the main study. The instrument questionnaire is seen in Appendix C.

3.5. Data analysis

For the adapted instrument, the same analyses were applied with the study done in English origin. Therefore, reliability and validity analyses were done. In the next sections, analyses are explained in detail.

3.5.1. Reliability analysis

Reliability means obtaining the same result consistently with different measurements. In order to declare that a test data is reliable, it needs to show an identical value for different measurements each time (Gravetter & Wallnau, 2013). Reliability can be found with many methods. To measure the internal consistency, Cronbach's alpha is one of the important determinants of the reliability. Many sources stated alpha value above 0.70 is acceptable, 0.80 or greater is preferred. It needs to be emphasized that the higher is the better (Cortina, 1993). Results which are closer to 1 mean the higher the internal consistency (George & Mallery, 2001).

3.5.2. Validity analysis

Validity refers to whether an instrument measure what is targeted to measure (Field, 2009). A validation is a process a test developer or user collects evidence to enforce inferences that are to be drawn based on test scores (Crocker & Algina, 1986). Four main types of validity are named as face validity, content validity, criterion validity, and construct validity (Taherdoost, 2016). Face validity is a degree for the appearance of a test. It evaluates the tests in different aspects including feasibility, readability, consistency of style, formatting, and language clarity. Content validity is described as the degree that each item in the instrument reflects the content which will be generalized. Criterion validity measures whether the instrument predicts well for another measure or not. This type of validity uses for predicting behaviors and performance in another situation such as past, present, and future. Construct validity measures performances that can be grouped under a theme of a certain psychological construct that are not directly observable (Crocker & Algina, 1986). Crocker and Algina (1986) explained four approaches that used for construct validation. These are correlation between a measure of the construct and designated, differentiation between groups, factor analysis and the multitrait-multimethod matrix. Taherdoost (2016) also stated that the construct validity has two components such as convergent and discriminant validity. While the discriminant validity test for the construct that has no relationship, convergent validity test for the constructs that are related. Factor analysis can be conducted in order to verify the construct validity (Taherdoost, 2016).

Confirmatory factor analysis (CFA), on the one hand, is the center for research that based on the construct validation. In a CFA, the researcher claims a hypothesis about a numeric value of some of the parameters of the factor analysis (Crocker & Algina, 1986). CFA explores measurement, dimensions, relations of a test. CFA is one of the forms of factor analysis in order to test a set of data whether the hypothesized organizational structure fits well or not (Urban, 2010). Hence, CFA is a tool that is used to confirm or reject the measurement theory.

Fit indices are used to evaluate goodness of the fit of the data to the proposed model. CFI (Comparative Fit Index), TLI (Tucker Lewis index) and RMSEA (Root Mean Square Error of Approximation) are widely used fit indices as they are less sensitive to the sample size. According to Ullman (2001), CFI and TLI values ranged between 0 to 1 and values over 0.95 refer to good fitting data. Also, Ullman (2001) mentions that RMSEA value smaller than 0.06 indicates a good fitting model.. He also added that ratio of a sample size to variable number is important for CFA and if the sample size small, then it is difficult to obtain a stable CFA result.. CFA analysis of this thesis was conducted with MPLUS 7.4 (Muthen & Muthen, 2015).

Exploratory Factor Analysis is commonly used in the fields of education and psychology and is considered the method of choice for interpreting self-reporting questionnaires. Three of the objectives of factor analysis are; factor analysis reduces a large number of variables into a smaller set of variables (also referred to as factors); secondly, it establishes underlying dimensions between measured variables and latent constructs, thereby allowing the formation and refinement of theory; thirdly, it provides construct validity evidence of self-reporting scales. SPSS is an appropriate program to determine the factor analysis of any data.

CHAPTER 4

RESULT

In this chapter, the results of the study are presented in four main sections. In the first section, descriptive analysis is explained. Second section covers psychometric analysis of the study in terms of reliability and validity analysis of the final version of the instruments. Lastly, comparisons made in the study are reported.

4.1. Descriptive analysis

The participants were 330 students. Before, the analysis, the outliers, and missing data were removed. Hence, 4 students were extracted from the data. Therefore, the data analysis was completed with 326 students. In the demographic parts of the instrument grade level, career choices, scientific hobbies, and school types were asked to the participants.

Students were asked to write the career choices that they thought. They gave several answers varied from football player to mechanical engineer. Hence, the answers collected from the participants were grouped as STEM-related and Not STEM-related career choices. The answers were coded if the jobs have any relation with science, technology, engineering, and math as STEM-related, and others as not STEM-related. As reported in Table 3, approximately half of the students would like to attend a career related to STEM fields and half of them do not aim to have any STEM-related career.

Table 3. Career Choices of the Sample

Career Choices Groups	N
Not STEM Related Career	165
STEM Related Career	161

Scientific hobbies also asked to the participants. The question asked is the number of popular science journals that they actively read each month. Most of the students answered the questions as 0 and 1 science journal, which are 130 and 137 students respectively. 38 of the students replied the question as they read 2 journals each month and the rest of them expressed that they actively read 3 or more journal each month.

Table 4. Journal Number that Read by the Participants

Journal Count	N	%
0	130	39.4
1	137	41.5
2	38	11.5
3	14	4.2
4	7	2.1
5	4	1.2
Total	330	100.0

A final question for the participants was their school type. They pointed out the answer as to whether public or private. The distribution of the school type was given in Table 2.

4.2. Psychometric analysis of the instrument

In this section, the psychometric analysis of the instrument is presented with the collected data. Reliability, validity, and factor analysis of the instrument is explained in the following parts.

4.2.1. Reliability analysis of the instrument

An important analysis for adaptation of the instrument was reliability statistics of 12 item instrument. According to statistical analysis, the reliability of the instrument (Cronbach's alpha = 0.828) pointed out the good internal consistency (George & Mallery, 2001) as seen in Table 5.

Table 5. Reliability Statistics

Cronbach's Alpha	N of Items
.828	12

Moreover, it is shown in Table 6 that Cronbach's alpha does not enhance with the deletion of any item. All items in the survey contributed to the internal consistency of its own. Only Item 4 is close to the Cronbach's alpha if deleted. A similar result was found during the reliability analysis of the pilot study. The item was below.

Item 4: Evimdeki teknoloji uzmanı benim. (I'm the technology expert in my house.)

Table 6. Item-Total Statistics

Item	Corrected Item-Total Correlation	Cronbach's Alpha If Item Deleted
Item 1	.514	.813
Item 2	.494	.815
Item 3	.491	.815
Item 4	.366	.827
Item 5	.495	.815
Item 6	.430	.820
Item 7	.520	.814
Item 8	.496	.815
Item 9	.572	.809
Item 10	.493	.815
Item 11	.516	.813
Item 12	.477	.817

4.2.2. Validity analysis of the instrument

Construct validity analysis for the adapted Turkish version of the instrument is investigated in this section (Muthen & Muthen, 2015). The original English version of the instrument was shown to have one-factor. Therefore, the data for the adapted version of the instrument was regarded as a one-factor model at the beginning and the same analysis was done. The result obtained through CFA model was marginally accepted for one factor model as seen in Table 7. (i.e., $\chi 2$ = 295.946, df = 54, p = 0.000; Comparative Fit Index [CFI]= 0.890; Tucker-Lewis Index [TLI] = 0.866; Root Mean Square of Approximation [RMSEA] = 0.117).

Table 7. Confirmatory Factor Analysis with One-factor

	$\chi 2$	d*f*	$\chi 2$/ d*f*	CFI	TLI	RMSEA
Model 1	295.946	54	5.480	0.890	0.866	0.117

4.2.3. Factor analysis of the instrument

The CFA result, as presented above, was regarded as marginally acceptable. Therefore, factors influencing goodness of fit values need to be searched. Even though the sample size is enough, and the reliability is good, the goodness of fit values was not as expected. Hence, exploratory factor analysis (EFA) was applied by using SPSS to see if it gives any clue for the structure of the adapted instrument (Green & Salking, 2016). As shown in Table 8, items 1, 8 and 9 were loaded to a different factor.

Table 8. Pattern Matrix

Item	Factor	
	1	2
Item 10	.647	
Item 11	.633	
Item 5	.596	
Item 6	.568	
Item 12	.513	
Item 3	.447	
Item 4	.437	
Item 2	.432	
Item 7	.420	
Item 8		-.782
Item 1		-.781
Item 9		-.656

These items were listed below.

Item 1: Sınıfta sorulan matematik sorularını çözebilirim.

(I can do math problems I get in class.)

Item 8: Matematik problemlerinde çözümlerimi açıklamakta iyiyim.

(I think I am very good at Explaining my solutions to math problems.)

Item 9: Problem çözmede iyiyim.

(I think I am very good at: Solving problems.)

The data structure in EFA suggested two factors and there is a need to conduct new CFA with two factors again. The fit of two factor model improved the result impressively (i.e., $\chi 2$ = 109.466, df = 53, p = 0.000; Comparative Fit Index [CFI]= 0.974; Tucker-Lewis Index [TLI] = 0.968; Root Mean Square of Approximation [RMSEA] = 0.057). This finding showed that the STEM Competency Belief's Instrument had two-factor structure as science-technology-engineering in one side and mathematics on the other side for the Turkish data.

Table 9. Confirmatory Factor Analysis with Two-factor

	$\chi 2$	d*f*	$\chi 2$/ d*f*	CFI	TLI	RMSEA
Model 2	109.466	53	2.065	0.974	0.968	0.057

4.3. Comparisons analysis

Comparative analyses using t-test were conducted to test mean score differences of related groups (gender, school type, and career choices) on these obtained factor scores.

4.3.1. Gender comparisons

An independent-samples t-test was conducted to compare the mean scores of male and female students on Science, Technology, and Engineering (STE) and Mathematics (Math) factors obtained from STEM Competency Beliefs Instrument. For STE, male and female students means are respectively M= 27.39 *(S.D=4.19)* and M= 26.71 *(S.D=4.44)* as shown in Table 10. Also, means of math for males and females are respectively: M= 9.23 *(S.D=2.19)* and M= 9.05 *(S.D=1.94)*.

Table 10. Male-Female Mean Differences

	Gender						95% CI for Mean Difference	t	df
	Male			Female					
	M	SD	n	M	SD	n			
STE	27.39	4.19	169	26.71	4.44	157	-1.61, .26	-1.41	324
Math	9.23	2.19	169	9.05	1.94	157	-.63, .27	-.78	323

Note. *p < .05. **p < .01

Independent sample t-test showed that the mean score differences for both STE and Math were not statistically significant and the effect size, d= 0.15 for STE, d= 0.08 for Math.

4.3.2. School type comparisons

School type is another variable and there are two types in the sample as public and private schools. Means of the students for STE attending public school and private school are respectively: M=26.85 *(S.D=4.32)* and M=29.75*(S.D=3.35)*. For math results, means are M=8.99 *(S.D=2.06)* and M=11.08*(S.D=1.06)* respectively. It is observed that the mean score differences between public and private school students are statistically significant for STE and Math.

Table 11. School Type Mean Differences

	School Type						95% CI for Mean Difference	t	df
	Public			Private					
	M	SD	n	M	SD	n			
STE	26.85	4.32	302	29.75	3.35	24	-4.67,-1.12	-3.20**	324
Math	8.99	2.06	302	11.08	1.06	24	-2.59,-1.59	-8.48**	38.61

Note. *p < .05. **p < .01

In order to assess the effect size of the differences, Cohen’s d is measured and concluded as d=0.75 for STE, and d= 1.27 for Math. The differences between public and private school groups are significant with large effect size for both STE and math (*d*>0.80) (Cohen, 1988; Gravetter & Wallnau, 2013).

4.3.3. Career choices comparisons

Career choices are the last variable that is investigated for the differences if there is any. Students were grouped into two according to their career choices as STEM-related and Not STEM-related. Means of the students in STEM-related group for STE is M= 27.91 *(S.D= 9.53)* and for Math is M= 9.53 *(S.D= 1.95).* Students whose career choices are not STEM-related has M=26.24 *(S.D=4.08)* for STE and M=8.76 *(S.D= 2.12)* for Math.

Table 12. Career Choices Groups Mean Differences

	Career Choices						95% CI for Mean Difference		
	STEM Related			Not-STEM Related					
	M	SD	n	M	SD	n		t	df
STE	27.91	4.41	161	26.24	4.08	165	-2.59, -.73	-3.53**	324
Math	9.53	1.95	161	8.76	2.12	165	-1.21, -.32	-3.40**	324

Note. *p < .05. **p < .01

Table 12 shows that there are statistically significant differences between the groups with t(324)= -3.53 *p* =.000 for STE and t(324)= -3.40 *p* =.001. Cohen’s d was calculated for the group and obtained *d= 0.4* for STE and *d= 0.38* for Math. It shows the group mean scores are not equal, and they have medium effect size.

CHAPTER 5

DISCUSSION

The instrument called in the English version as STEM Competency Beliefs was translated and adapted into the Turkish content. Responses coming from the Turkish students were coded and analyzed in order to demonstrate the equivalence of the Turkish version of the test with the origin. Findings for each analysis provided evidence that the Turkish version of the test was equivalent to the English version with no significant differences. Hence, all parts including pilot study feedback, age group, and sample size, scoring method, reliability and construct validity analysis, factor analysis with differences are discussed in detail respectively.

To begin with the pilot study and its feedback, it was one of the first steps in the study to translate and adapt the survey. Translation process was quite interdisciplinary. The process included one English teacher and one interpreter for the forward technique; two bilingual English citizens for the backward technique; one English linguist to compare forward and backward translations and one Turkish editor to control the fluency and clarity of the translated items. Also, for all the forward and backward translations consensus meetings were held and one associate professor in science education, one assistant professor in statistics and one science teacher attended to those meetings. Even with an intensive working on the translation, the pilot study was significantly important to continue with the test. The pilot study was done with 77 students and their opinions about the items were archived. Except for two students, 75 of them wrote that all questions were clear enough to understand. The two students, on the other hand, wrote items that they struggle in their lives. Also, they mentioned that the word “website” is not clear for them. The misunderstanding was rectified with my explanation and all of the questions were confirmed by students as clear. Then, the word “website” changed with “internet sitesi” for the main study.

Continuing with the age group and sample size in the analyzed data, the original version of the test was used as a guide to determine the target group. Authors of the test, Chen, Cannady, Shun, and Dorph (2017), suggested 10-14-year-old respondents for the survey. In Turkish context, suggested age group refers to the 5^{th}-8^{th} graders in general. Also, the authors stated for the sample size that the result of the test based on 205 middle school students. In Turkish context, on the other hand, the sample consisted of 330 students who were visitors to a science center in Turkey. The size of the groups in both cases was close to get similar results.

The scoring method was another issue that is mentioned in the original journal (Chen, Cannady, Shun, & Dorph; 2017). They began to score each item with 4 and continue with 3, 2 and 1 which means better to worse. In Turkish, we coded the responses as the same in the original version. While using different and appropriate words for each item, we changed some options for some questions in the survey. To give an example, the test designer gave options as “Yes!”, “Yes”, “No” and “No!” from 6^{th}-12^{th} questions. However, in the Turkish version, we changed them as “Definitely Agree! - *Kesinlikle Katılıyorum*”, “Agree-*Katılıyorum*”, “Disagree-*Katılmıyorum*” and “Definitely Disagree!- *Kesinlikle Katılmıyorum*” in order to give the essence of the language. Besides that, the designer of the test offered to sum of the items to use the score, the same was done for the Turkish version.

The analysis is an important issue for the translation process of a test. Sample in the study with 4 missing data was 326 students and their responses showed that reliability analysis meets the criteria with 0.828 Cronbach's alpha value. The result of the reliability analysis provided evidence for adequacy of the items in the translation and adaptation of the instrument. Validity analysis, on the one hand, proceeded with confirmatory factor analysis and CFI, RMSEA, and TLI values were checked out. In English version of the instrument, values were listed mainly as CFI= 0.974, RMSEA=0.052, TLI= 0.969 and the obtained values in the Turkish version of the instrument were CFI= 0.974, RMSEA=0.057, TLI= 0.968. As seen in the results, the findings were same or similar to each other in two different versions. It can be exactly concluded that the Turkish version of the STEM Competency Beliefs instrument was trans literally equivalent to the original one and can be used for further investigations.

One important difference exposed to findings were related to factor analysis. Originally the instrument was reported as one factor in all analyses (Chen, Cannady, Schunn & Dorph, 2017). The instrument used in Africa, Zambia. However,the official language in Zambia is English, hence they did not adapt the test. Their statistical analysis also shows one factor structure for their data (M.Cannady, personal communication, November 12, 2018). Moreover, the instrument translated into Spanish also, but, as developers of original instrument declared they got the same result in Spanish version as well. However, as it was observed in the Turkish version of the test, it has two dimensions. Exploratory factor analysis showed three items that were separated and strongly correlated in each other. These items were shown as 1st, 8th, and 9th items in the test. The items were listed in Table 13 below with both the Turkish and English versions.

Table 13. Items of the Second Factor

Item Number	Turkish Version	English Version
1	Sınıfta sorulan matematik sorularını çözebilirim.	I can do the math problems I get in class.
8	Matematik problemlerinde çözümlerimi açıklamakta iyiyim.	I think I am very good at: Explaining my solutions to math problems.
9	Problem çözmede iyiyim.	I think I am very good at: Solving problems.

It is clearly seen in Table 13 that items that separate and correlate each other are related to Mathematics. It should be also added that the rest of the survey is based on science and technology concepts for children. Mathematics and problems are only mentioned 1^{st}, 8^{th}, and 9^{th} items in the whole survey. It can be argued that there is a sharp distinction in STEM perceptions of Turkish students as math in one group and science, technology and projects in other groups, not an interdisciplinary view as a STEM expectation.

Ministry of Education in Turkey has launched a report about STEM education in recent years. There are some points that can explain the two-factor structure that the findings showed. In the report, the aim of STEM education is stated as full integration of disciplines and interdisciplinary perspectives are recommended when adapting the STEM in Turkey. On the other hand, it is also declared that Turkey does not have a direct STEM action plan in 25 countries that most of them have a concrete strategy plan and action mentioned in the report (MEB, 2016). Hence, students in Turkey have difficulty to perceive STEM as a whole.

Besides that, students in Turkey do not have STEM courses in their schedule rather they have Science and Technology, Mathematics, Scientific Practices, and Mathematics Practices. Recently, the name of the course was revised as Science and another course named as Technology and Design was added. Also, in new revisions of the national curriculum, there is statement emphasizing the "science, technology, engineering" in one hand, and mathematics on the other hand (MEB, 2018c-d). This might be an explanation of why students consider STEM fields in two groups.

Ercan, Altan, and Dağ (2016) mention about the same topic in their study. They explain the aim of STEM as the integration of science, technology, engineering, and math which are taught separately in Turkey. Even though the idea of integration of disciplines is clear, it is somewhat problematic in school settings in terms of curricular and pedagogical issues. Because of the structure of the curricula in Turkey, science and math courses are isolated disciplines which makes the integration difficult. Additionally, science and math have established standards in K-12 curriculum, but technology and engineering disciplines have not. It leads to integrate STEM into science and math courses which are already existent in the content. However, science and math teachers are specialized with their own subjects and need to develop their proficiencies in integrated STEM education with pedagogical perspectives. Han, Yalvac, and Capraro (2015) also emphasized the importance of pedagogical development for teachers in their study. All the problems seen about STEM application in Turkey may lead students not to comprehend STEM in an actual manner.

Baran et al. (2016) studied for the STEM education out of school in Turkey. They mentioned that STEM is mainly interpreted as science and math so engineering and technology are neglected. Moreover, they asserted the main concerns of national curricula in Turkey is raising science and math literate students. Colakoglu (2016) also stated that Turkey does not have a plan about STEM program at the national level but organization level, for instance, The Scientific and Technological Research Council of Turkey (TUBITAK) increases the activities by funding science and technology centers, science fair program, out of school STEM activities. Briefly, researches indicate that Turkey does not have a common value at the national level for STEM education that influences teachers and students to construct an integrated perception of the program.

Furthermore, STEM self-efficacy beliefs are compared in samples in terms of gender, school type, and career choices.

Firstly, on the contrary to the literature (Hackett & Betz, 1982; Telhed, Backström & Björklund, 2016; Zeldin, Britner & Pajares, 2006), gender was observed as no differences in between for the participants for both STE and Math factors in Turkey. An explanation might be related to the age of the participants. The studies focused on gender as a variable working with high school students which is higher than our study sample. Hence it might have an influence on their thoughts and female students feel as comfortable as male students in middle school years.

Secondly, according to the observations, school type was a significantly different effect on students that study in public and private schools for STE and Math. This result could be explained in terms of the students' opportunities in their learning environments, teachers' professional development. Besides, class sizes vary in public and private schools in Turkey. Many private schools studied on STEM education and declared their activities on their website. They have STEM laboratories, they worked for robotics and technology competition in the national and international level. Most of them have after school science and technology clubs. These are all activities and opportunities may have positive influence of students' self- efficacy beliefs towards STEM fields and the finding consisting with the literature (Billiar, Hubelbank, Oliva & Camesona,2014; Chittum et al., 2017; John et al., 2016; Monterastelli et al. 2011). Also, as stated in the literature, teachers have a significant factor influence on students' achievements (Corlu Capraro & Capraro, 2014). Teachers working in private schools have more opportunity to take STEM-related professional development courses provided by schools. On the other hand, public schools mostly depend on the awareness of teachers who work with students. Even there is an elective course named as Applied Science, opening the course depends on schools' and teachers' preferences. The last reason may influence on student learning is the class size. In the literature, it is stated that smaller class size has positive effect on students' academic performance (Brühwiler & Blatchford, 2011). In Turkey, private schools have smaller class size regarding to public schools. Hence, class size may also have an influence on students' perceptions.

A final comparison was about the career choices of students as STEM-related and not STEM-related. It was observed that students who have a career choice related to STEM fields have higher self-efficacy beliefs on STEM. It may demonstrate that the instrument is able to measure what needs to be measured. Because, it is expected that students who have career choices related to STEM fields, need to have higher self-efficacy beliefs about the fields self-efficacy.

In brief, the study showed that STEM Competency Beliefs Instrument was adapted into the Turkish version and its' psychometric analysis was completed. The study shows that the instrument was reliable and valid to use for further research and investigation. Educators, teachers, and researchers can utilize the STEM Competency Beliefs instrument in schools or STEM centers. Hence, the present study contributes to further studies related to STEM education in Turkey.

APPENDIX A

PARTICIPANT INFORMATION AND CONSENT FORM

Araştırmayı destekleyen kurum: Boğaziçi Üniversitesi
Araştırmanın adı: BTMM Özyeterlik İnancı Anketinin Türkçe'ye Çevrilmesi ve Adaptasyonu
Proje Yürütücüsü: Doç.Dr. Ebru Zeynep MUĞALOĞLU
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Telefonu: +90 (212) 359 45 60
Araştırmacının adı: Cansu Demirtaş Demirbağ
E-mail adresi: cansu.demirtas@boun.edu.tr
Telefonu: 0506 463 12 24
Sayın Veli,

Boğaziçi Üniversitesi'nde İlköğretim Bölümü'nde yüksek lisans tez çalışmamı yürütmekteyim. Bu çalışmada Bilim, Teknoloji, Matematik ve Mühendislik alanlarında öz yeterlik ölçeğinin Türkçe'ye çevrilmesini ve adaptasyonunu gerçekleştirmeyi hedeflemekteyiz. Ölçek 12 madde ve her maddeye ilişkin 4 farklı seçenekten oluşmaktadır. Ankette, öğrencilerin proje çalışmalarında, günlük problemler ile karşılaştıklarında ya da matematik eğitimlerinde kendilerini değerlendirmeleri istenmektedir. Orta okul öğrencileri çalışmanın örneklemi olarak belirlenmiştir. Bu sebeple, velisi bulunduğunuz öğrencinin araştırmaya katılımını rica ederiz.

Araştırma projesi hakkında ek bilgi almak istediğiniz takdirde proje araştırmacısı **Cansu Demirtaş Demirbağ** veya proje yürütücüsü Boğaziçi Üniversitesi Matematik ve Fen Bilimleri Eğitimi Bölümü Öğretim Üyesi Doç.Dr. Ebru Zeynep Muğaloğlu ile temasa geçiniz. Araştırmayla ilgili haklarınız konusunda yerel etik kurullarına da danışabilirsiniz.

Onay Bildirimi:

- Araştırmanın sonuçları **akademik amaçlar** için kullanılacaktır.
- Bu araştırmada toplanan veriler **gizli tutulacaktır**.
- Öğrencilerin yanıtlarının notlar üzerinde herhangi bir etkisi olmayacaktır.
- Araştırmaya katılması karşılığında tarafınıza herhangi bir ödeme yapılmayacaktır.
- Velisi bulunduğunuz öğrencinin araştırmaya devam etmesini istemediğiniz durumlarda o zamana kadar toplanmış olan tüm veriler imha edilecektir.

Araştırmanın amacı konusunda bilgilendirildim ve sorumlu olduğum öğrencinin araştırmaya katılmasına izin veriyorum.

Öğrencinin adı soyadı:

____

Öğrenciden sorumlu kişinin adı soyadı:

____

İmza:

____

Tarih:

____

APPENDIX B

PERSONAL INFORMATION QUESTIONNAIRE

Bu araştırma bilim, teknoloji, matematik ve mühendislik alanlarında yapılan eğitim çalışmalarına katkı sağlamak amacıyla yapılmaktadır. Cevaplarınız gizlilik gereğince saklı tutulacak ve araştırmacılar dışındaki herhangi biriyle paylaşılmayacaktır.
Lütfen bu soruları, kendi tutum ve davranışlarınızı düşünerek **samimi** bir şekilde cevaplayınız.
Bilimsel çalışmalara destek olduğunuz için teşekkür ederiz.

KİŞİSEL BİLGİLER				
Adınız Soyadınız				
Okul Türünüz	Devlet Okulu: ◯		Özel Okul: ◯	
Devam Etmekte Olduğunuz Sınıf	5: ◯	6: ◯	7: ◯	8: ◯
Cinsiyetiniz	Kız: ◯		Erkek: ◯	

GENEL BİLGİLER
Takip ettiğiniz dergi(leri) işaretleyiniz. ☐ Bilim Çocuk ☐ Bilim Teknik ☐ Popüler Bilim ☐ Araştırmacı Çocuk ☐ Bilge Çocuk ☐ National Geography Kids ☐ Çırak

Sevdiğiniz ders(leri) işaretleyiniz. ☐ Sosyal Bilgiler ☐ Matematik ☐ Fen Bilimleri ☐ Bilişim ve Teknoloji ☐ Diğer
Gezmeyi sevdiğiniz yerleri işaretleyiniz. ☐ Bilim Merkezi ☐ Planetaryum ☐ Müze ☐ Botanik Bahçesi ☐ Diğer
Gelecekte hangi mesleği yapmak istiyorsun? Neden? ………………………………………………………………………………… ………………………………………………………………………………… ………………………………………………………………………………… …………………………………………………………………………………

APPENDIX C

INSTRUMENT QUESTIONNAIRE

1- Sınıfta sorulan matematik sorularını çözebilirim.			
○ Her zaman	○ Çoğu zaman	○ Bazen	○ Nadiren

2-Benim yaşımdaki çocuklar için hazırlanmış internet sitelerindeki bilimsel içeriği anlayabilirim.			
○ Tüm websitelerindekini anlayabilirim.	○ Çoğu websitelerindekini anlayabilirim.	○ Bazı websitelerdekini anlayabilirim.	○ Hiçbirini anlayamam.

3- Fen ve teknoloji kulübünde kendi projemi yapıyor olsaydım, bu proje…….. bir proje olurdu.			
○ Çok iyi	○ İyi	○ Orta	○ Zayıf

4- Evimdeki teknoloji uzmanı benim.			
○ Her zaman	○ Çoğu zaman	○ Bazen	○ Nadiren

5- Yetişkinler için yazılmış bilimsel kitapların içeriğini anlayabilirim.			
○ Her zaman	○ Çoğu zaman	○ Bazen	○ Nadiren

6- Çalışmayan şeylerin nasıl tamir edileceğini çözmekte iyiyim.			
○ Kesinlikle katılıyorum.	○ Katılıyorum.	○ Katılmıyorum.	○ Kesinlikle katılmıyorum.

7- Fikrimi söylerken kanıtlar sunmakta iyiyim.			
○ Kesinlikle katılıyorum.	○ Katılıyorum.	○ Katılmıyorum.	○ Kesinlikle katılmıyorum.

8- Matematik problemlerinde çözümlerimi açıklamakta iyiyim.			
○ Kesinlikle	○ Katılıyorum.	○ Katılmıyorum.	○ Kesinlikle

katılıyorum.			katılmıyorum.

9- Problem çözmede iyiyim.			
○ Kesinlikle katılıyorum.	○ Katılıyorum.	○ Katılmıyorum.	○ Kesinlikle katılmıyorum.

10- Kendi kendime bilimsel keşifler yapmakta iyiyim.			
○ Kesinlikle katılıyorum.	○ Katılıyorum.	○ Katılmıyorum.	○ Kesinlikle katılmıyorum.

11- Teknik problemleri çözmek için yeni yollar bulmakta iyiyim.			
○ Kesinlikle katılıyorum.	○ Katılıyorum.	○ Katılmıyorum.	○ Kesinlikle katılmıyorum.

12- Proje üzerinde çalışırken yeni fikirler bulmakta iyiyim.			
○ Kesinlikle katılıyorum.	○ Katılıyorum.	○ Katılmıyorum.	○ Kesinlikle katılmıyorum.

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