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DOES STEM EDUCATION HAVE AN IMPACT ON PROBLEM SOLVING SKILL?*

STEM EĞİTİMİ PROBLEM ÇÖZME BECERİLERİNİ ETKİLER Mİ?

Abstract: Education strategies are impacted by the development of technology and economy. STEM education is gaining more importance thanks to the changes in technology because technological changes reveal the need for mathematics, science, engineering and technology disciplines. Besides, problem-solving skills are one of the skills that children are required to have. Children can produce new solutions to changes thanks to their problem-solving skills. In many studies, it is seen that STEM education supports children's problem solving skills, which is one of the 21st century skills. In addition the engineering design process used in STEM

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and the problem-solving steps are similar. Thus, the problem solving skills are supported and developed thanks to STEM. This study is a review article aiming to examine the relationship between STEM based on engineering design process and problem solving skills. In addition, the study examines the studies about STEM and problem solving skills on Turkey.

Keywords: STEM, Problem solving skills, Education, 21st Century Skills, Engineering Design Process

Öz: Eğitim stratejileri, teknoloji ve ekonominin gelişiminden etkilenmektedir. Teknolojik değişimler ise matematik, fen, mühendislik ve teknoloji disiplinlerine olan ihtiyacı ortaya çıkartmıştır. Böylece bu disiplinleri barındıran STEM eğitimi, teknolojideki değişiklikler sayesinde önem kazanmaktadır. Ayrıca problem çözme becerileri, çocukların sahip olması gereken becerilerden biridir. Çocuklar problem çözme becerileri sayesinde farklı durumlarda yeni çözümler üretebilirler. Yapılan birçok araştırmada STEM eğitiminin 21. yüzyıl becerilerinden biri olan problem çözme becerilerinin gelişimini desteklediği görülmektedir. STEM eğitiminde kullanılan Mühendislik Tasarım Süreci ve Problem Çözme Basamakları ise oldukça benzerdir. Böylelikle çocukların kazanmaları gereken problem çözme becerileri STEM sayesinde desteklenmekte ve geliştirilmektedir. Bu çalışma, mühendislik tasarım süreci temelinde STEM ve problem çözme becerilerinin ilişkisini incelemeyi amaçlayan bir derleme makalesidir. Ayrıca çalışma Türkiye'deki ilgili çalışmaları da incelemektedir.

Anahtar Kelimeler: STEM, Problem Çözme Becerileri, Eğitim, 21. Yüzyıl Becerileri, Mühendislik Tasarım Süreci

INTRODUCTION

Technological and economic innovations, which have gained importance today, have been used in many fields, and have become a necessity for development. For example, new technological products produced during World War II by scientists, mathematicians and engineers enabled to win the war (White, 2014). In addition, the launch of Sputnik, which is the first satellite of Soviet Russia, was the beginning of a new era in terms of technological developments. After that, the United States moved their targets further by establishing the National Aeronautics and Space Administration (NASA) (White, 2014). In the light of all these developments, the National Science Foundation (NSF) for 'science, mathematics, engineering and technology' disciplines used SMET acronym in the early 90s (Breiner, Harkness, Johnson and Koehler, 2012; Sanders, 2009). However, this abbreviation, which is similar to other terms, changed over time, and started to be used as STEM in 2001 (Breiner et al., 2012).

STEM is an interdisciplinary approach based on science, technology, engineering and mathematics disciplines (Breiner et al., 2012). The essentiality in STEM education is that individuals produce solutions for engineering problems by using science and mathematics knowledge and by applying to technology (Kennedy & Odell, 2014). In this context, STEM disciplines allow for new discoveries especially in the industry (White, 2014). Occupations including STEM discipline providing these inventions have been identified, and the need for these

occupations has increased day by day (Aydagul & Terzioglu, 2014). Thus, one of the aims of STEM is to contribute to economy for the countries and to create a workforce providing development (Sanders, 2009; Kelley & Knowles, 2016). Creating the requested workforce is realized through education programs including STEM education and 21st century skills such as problem solving, creativity, communication and critical thinking. Thanks to these programs, STEM education with an interdisciplinary perspective will contribute to the training of individuals with 21st century skills that countries need (Erdogan, Ciftci, Yıldırım & Topcu, 2017).

In some studies, it is observed that STEM education develops children's skills such as academic success, problem solving, conceptual knowledge, and self-efficacy at all levels of education (Cooper & Heaverlo, 2013; Soylu, 2016; Pekbay, 2017; Nagac, 2018; Ozturk, 2018 Worker, 2018). In this context, educating individuals with 21st century skills is becoming more and more important today, and STEM integration in education is emphasized (Aydagul and Terzioglu, 2014; Uyanık Balat & Gunsen, 2017). Especially, the relation of problem solving skills, which is one of the 21st century skills, with STEM is becoming an increasingly important topic. Accordingly, the contribution of STEM education to problem solving skills has been a field that is studied on. On the other hand, the engineering design process followed in STEM education and problem solving steps are similar. Thus, STEM education and engineering design process used in this process supports problem-solving skills.

In general, the contribution of STEM education to problem solving skills is of great importance for educating individuals with 21st century skills. Today, thanks to STEM, both individuals are trained for the desired workforce and it is possible to develop their problem-solving skills. Thus, the aim of this study is to review the relation of STEM education with children's problem solving skills, and its contribution to this skill.

STEM (SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS)

Despite of the consensus that STEM education includes science, technology, engineering and mathematics disciplines, there is no certain definition accepted by all. When the current definitions of STEM education are examined, Bender (2018) defined STEM education as solving real-life problems by group or individually in scientific ways. It is also emphasized that STEM education is an intertwined and complementary whole of science, technology, engineering and mathematics disciplines (Basham & Marino, 2013). As for the details, STEM education is an interdisciplinary approach that enables the education of individuals with 21st century skills and the development of high cognitive skills (Erdogan et al., 2017). In this sense, STEM education is emphasized as an approach that can be defined as the interdisciplinary use of at least two disciplines of science, technology, engineering and mathematics (Corlu, Capraro & Capraro, 2014; Kelley & Knowles, 2016; Sanders, 2009). However, it is also argued that although the definition of STEM education includes science, technology, engineering and mathematics disciplines, it isn't limited to these disciplines. In addition to these four disciplines, it was explained that social development, language development, art and many more fields must be benefited (Bybee, 2010; Sanders, 2009). In addition, STEM education is defined as producing solutions to engineering problems by using science and mathematics knowledge and applying to technology (Kennedy & Odell, 2014).

Considering the definitions about STEM education, it might be concluded that there is cooperation between science, technology, engineering and mathematics disciplines (Brown, 2012). In addition, some other disciplines can be combined in STEM education but science, technology, engineering and mathematics disciplines are always in the center of STEM education. When examined STEM definitions in Turkey, it is seen that some researchers use FeTeMM term instead of STEM because the initials of FeTeMM is the initials of Science, Technology, Mathematics and Engineering words in Turkish language. However, although the term differs, the common point in defining this education is that education should be interdisciplinary and include solution-oriented daily life problems (Akgunduz et al., 2015).

THE PURPOSE AND IMPORTANCE OF STEM EDUCATION

There is a new competition as the result of economic and technological developments in the world. In this context, finding workforce that keep up with these developments became a priority in the era of Industry 4.0. The required workforce must be individuals with 21st century skills such as self-regulation, problem solving, collaboration and systematic thinking, and the workforce must be able to keep up with the developing world (Bybee, 2010). Therefore, new education policies are becoming important to educate the required workforce and to provide these individuals with the necessary skills (Ritz & Fan, 2015). Because workforce is important in developing economy, and the disciplines which are science, technology, engineering and mathematics are now the required labor disciplines (Chesloff, 2013). Thus, the occupations including these disciplines became prominent, and it has been a duty for education field to educate individuals as desired workforce who can fulfill the requirements of these occupations (Langdon et al., 2011). Considering all these requirements, STEM education is emphasized, which addresses science, technology, engineering and mathematics disciplines from an interdisciplinary perspective to educate these individuals, and enables to educate individuals with 21st century skills (Akgunduz et al., 2015). In this context, STEM education has many different purposes. One of the main objectives of STEM education is to create a workforce to help economy and development of countries (Kelley & Knowles, 2016). It is also aimed to ensure that this workforce is raised as an innovative generation (Corlu, Capraro & Capraro, 2014). Finally, with STEM education at all levels of education, it is aimed to raise a new generation that can ask question, search, produce, and solve the problems with their own efforts by making use of science, technology, engineering and mathematics (Ministry of Education, 2016a).

STEM education has gained more and more importance with the aim of educating individuals who can keep up with innovations and have 21st century skills. When the achievements of the countries in science, technology, engineering and mathematics disciplines especially in international platforms are examined, it is concluded that STEM education must be given importance. The importance of TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme For International Student Assessment) researches that are conducted at international level and address science and mathematics disciplines, which are among STEM disciplines, is gradually increasing. Therefore, while emphasizing the importance of STEM education, it is important to mention these studies in order to explain the current situation.

TIMMS is a research that is implemented every four years since 1995 by the Interna-

tional Association for the Evaluation of Educational Achievement-IEA. This research focuses on assessing knowledge and skills of students at 4th and 8th grades on science and mathematics (Mullis and Martin, 2017). Referring to the results of the TIMSS in 2015, it was found out that Turkey was below the average in science and mathematics scale. When examined the results of the mathematics field, it is seen that the average of the students at 4th grade is below the midpoint of the scale, which is 500 points, with 483 points, and ranks 36th out of 49 countries. It is also seen that the average of the students at 8th grade is below the midpoint of the scale, which is 500 points, with 458 points, and ranks 24th out of 39 countries (Ministry of Education, 2016c). When the results of the science field is examined, it is seen that the average of the students at 4th grade is below the midpoint, which is 500 points, with 483 points, and ranks 35th out of 47 countries, and the average of the students at 8th grade is below the midpoint of the scale, which is 500 points, with 493 points, and ranks 21st out of 39 countries (Ministry of Education, 2016c)

PISA is an educational research carried out by the Organization of Economic Cooperation and Development (OECD) every three years since 2000. Measurement the skills of 15-year-old students in science, mathematics and reading is aimed with PISA (Ministry of Education, 2016b). Looking at the results of PISA research conducted in 2015, it is seen that Turkey was below OECD average, which was 493, with 425 points in science. Turkey was below OECD average, which was 490, with 420 points in mathematics, and Turkey was below OECD average, which was 493, with 428 points in reading skills. Furthermore, in PISA research attended by 70 countries, Turkey was the 51st in science, 48th in mathematics, and 49th in reading skills (OECD, 2015).

When TIMSS and PISA results are analyzed, it is seen that countries with large economies such as China, Japan and America rank high in these results (OECD, 2015; Ministry of Education, 2016c). When economically large countries are examined, it is seen that there are societies that can meet the requirements of the occupations called as STEM professions, and attach importance to educate individuals with 21st century skills (Ostler, 2012). Thus, it is emphasized that the importance given to STEM education will have positive effect on economy (Roberts, 2012). In this context, when the results of TIMSS and PISA assessing mathematics and science fields, in order to go even further in the economy, STEM education must be given importance to improve economy in Turkey.

STEM EDUCATION AND 21ST CENTURY SKILLS

The technological developments that emerged with Industry 4.0 age became the focus of attention around the world. Technological developments increased the competition between countries, and created a ground for further progress, especially in the field of technology. These developments are linked to STEM education disciplines which are science, technology, engineering and mathematics. In order to meet the requirements of the 21st century, individuals who master STEM disciplines, and have technological and personal competencies are preferred as workforce (Bybee, 2010). For this reason, occupation varies across the world. Today, current occupations such as engineering and computer programming based on science, technology, engineering and mathematics disciplines, and known as STEM professions, and the occupations that are supposed to emerge soon such as nuclear technician, cartography and photogrammetry

are becoming increasingly important (Langdon et al., 2011). However, individuals characteristics required to work in these occupations also show change and development.

Individuals need to improve daily life, career and learning skills in order to keep up with the developing Industry 4.0 age (Beers, 2011). These skills are called 21st century skills, and STEM education is essential to educate individuals with these skills (Akgunduz et al., 2015). However, there is no exact and accepted explanation of 21st century skills.

Allen and Van der Velden (2012) explained 21st century skills as collaboration, communication, technological skills, cultural skills, problem solving skills, creativity and critical thinking. However, Kennedy and Odell (2014) defined 21st century skills as life and career skills including problem solving, creativity, leadership, critical thinking, global awareness, productivity, communication, information literacy, collaboration, media literacy, technology literacy and responsibility skills. On the other hand, 21st century skills are emphasized as engineering based problem solving skill, communication, engineering based design skill, creativity, digital competence and cooperation (Sen, Sonay & Kıray, 2018). Considering all the explanations, it can be said that 21st century skills are considered with different perspectives. In this context, one of the most accepted explanations in the literature about 21st century skills was made by Partnership for 21st Century Skills. These skills are given in Figure 1 (Partnership for 21st Century Skills, 2019).

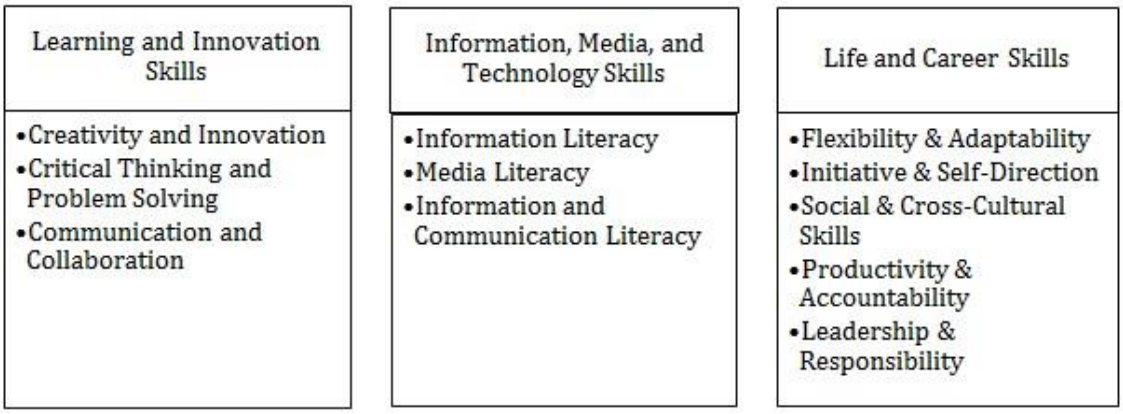

FIGURE 1. *Partnership for 21st Century Skills (Partnership for 21st Century Skills, 2019)*

PROBLEM SOLVING

The word, problem, comes from the Greek word "problema", which means obstacle (Jonassen, 2011). Considered from the origin, problem is the obstacles that occur when a goal is targeted or when it is strived for a purpose (Basaran, 1994; Bingham, 1983). In addition, problem is defined as the difference between situations what individual is and what individual wants to be (Robertson, 2017). In general, problem is a situation or event that creates difficulties for individual (Jonassen, 2011). Therefore, problem is an obstacle that requires individuals to question the situation and to make individual efforts to eliminate it (Dostál, 2015). Although there are different definitions of problem, there are three basic features that a situation must have in order to be considered as a problem. These features can be listed as follows:

1) The problem is an obstacle or difficulty that forces person on the way to goal,

2) The individual has a need and an intrinsic motivation to solve the obstacle or difficulty that is faced.

3) The individual has no preparation for a solution (Bingham, 1983; Kesicioglu, 2015).

After encountering the problem, individual tries to eliminate this problem and to achieve the purpose. This effort appears as a problem-solving process (Basaran, 1994; Bingham, 1983; Oguz, 2012). In addition, problem solving is defined as a purposeful cognitive process to eliminate obstacles and to achieve results (Dostál, 2015; Jonassen, 2011; Robertson, 2017). In this context, problem solving is also emphasized as an individual learning and development process (Bingham, 1983; Oguz, 2012).

Problem solving is a skill that individuals must have throughout their life. (Bingham, 1983). In addition, this skill is a process learned since early childhood with observations and experiences (Polya, 1997). In addition, one of the most important developmental features of early childhood is problem solving (Karayol & Temel, 2018) because children form the basis of learning with problem solving (Oguz, 2012). Thus, children learn to reach a solution by using both internal and external sources with the help of problem solving process (Bingham, 1983). For this reason, problem-solving process must be supported to provide children with cognitive development (Aldan Karademir, 2019). Thus, development since early childhood will produce positive effects in later years.

On the other hand, problem solving skills are not innate but develop with experiences and relations (Karayol & Temel, 2018). Problem solving skill is the ability to solve a problem or an obstacle (Yılmaz, Ural & Guven, 2018). For this reason, it is essential to develop problem-solving skills from an early age so that individuals do not have adaptation problems. Thus, supporting problem-solving skills from early ages is of great importance for the development of this skill (Yılmaz, Ural and Guven, 2018). Because supporting problem-solving skills from an early age is very crucial for solving social complexities, preventing unwanted behaviors and preventing peer conflicts (Karayol & Temel, 2018). Therefore, supporting problem-solving skills of children from early ages is of great importance for development of children. In order to provide children with problem solving skills from early ages, it is necessary to prepare appropriate educational environments and activities (Karayol & Temel, 2018).

PROBLEM SOLVING STEPS

Problem solving process is a complex process. For this reason, certain steps must be followed (Sahin, 2015). However, there are no strictly defined steps related to the problem solving process. Bingham (1983) listed problem solving steps as six steps: identifying the problem, explaining the problem, collecting data about the problem, selecting and organizing data, identifying possible solutions and assessing different ways of solutions. Gelbal (1991) defined the problem solving steps as noticing the problem, defining the problem, producing alternative solutions, and applying the solutions. In addition, hearing the problem, recognizing the problem, searching for a solution, decision making, implementing the decision and assessing the solution are defined as problem solving steps (Basaran, 1994).

Polya (1997) outlined the problem with the steps as noticing the problem, making plan, implementing the plan and assessing the outcome of the plan. Jonassen (2011) also defines problem solving steps as defining the problem, searching possible solutions, implementing solutions, regarding and assessing the solutions. Considering all these explanations, all of these stages are similar to Dewey's (1910) problem solving steps as noticing the problem, identifying the problem, collecting data for problem solution, determining the solutions for the problem, choosing the most appropriate solution, and reaching the result by solving the problem. It is also emphasized that the problem solving steps determined in this context are frame steps. However, there is no certainty that every step is always applied or applied in the same order. Steps can be combined or some of them might be skipped (Bingham, 1983). Thus, the problem solving steps in general can be listed as shown in Figure 2 (Sahin, 2015).

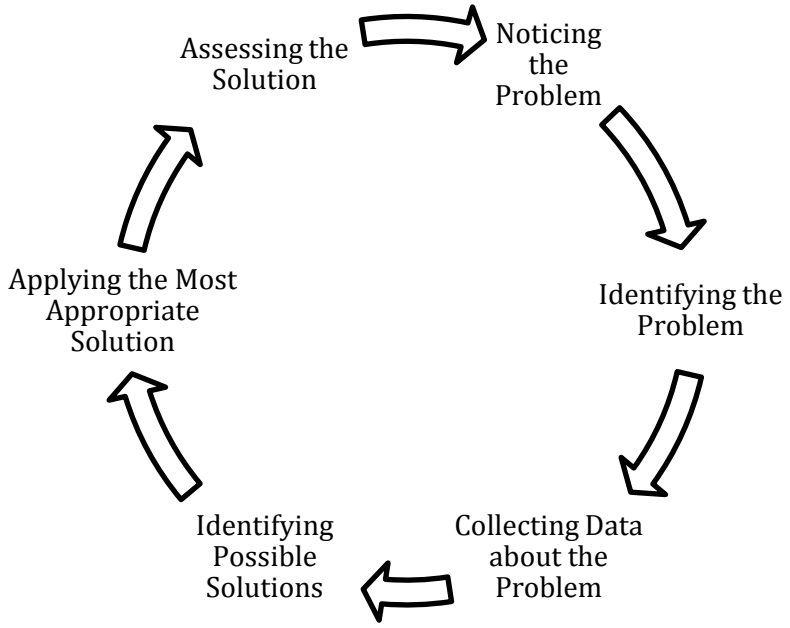

FIGURE 2. *The Problem Solving Steps*

Noticing the Problem: Although some problems can be clearly understood, some efforts are required to notice some other problems. In this context, it is important to think deeply in disturbing situations and to notice the real problem (Bingham, 1983).

Identifying the Problem: Once a situation is noticed as a problem, identifying the problem both saves time for the solution, and sometimes allows to understand whether there is a problem (Bingham, 1983). In addition, identification of the problem will be a guide in understanding the cause of the problem and in collecting the necessary data for possible solutions (Sahin, 2015).

Collecting Data about the Problem: After the problem is noticed and identified, it is necessary to conduct a multi-dimensional research on the problem before solution ways (Basaran, 1994; Bingham, 1983). In the solution process of a problem, the necessary information about the cause, limitations and importance of the problem is collected, and a suitable environment is

prepared to find the appropriate solutions for the problem. In addition, collecting the necessary data about the problem allows the individual to organize solution ideas and to consider the problem from different perspectives (Bingham, 1983).

Identifying Possible Solutions: By collecting information about the problem, information to solve the problem is also collected. Then, by reviewing this information, similar solutions are clustered, and possible solutions are created. Thus, solutions that can lead to the results in the process of solving the problem are determined (Sahin, 2015). In addition, when the solution does not bring an end to the problem, if many possible solutions are determined, it will provide the return to this step, and will speed up the process of trying new solutions (Bingham, 1983).

Applying the Most Appropriate Solution: After determining many solutions related to the problem, the solution that will bring an end in the fastest and the most effective way is decided and applied (Basaran, 1994). In order to avoid instability in this step, information about the problem should be carefully collected, and the solutions should be determined.

Assessing the Solution: After choosing and applying the most appropriate solution in the problem-solving process, it is checked whether this solution eliminates the problem. Thus, in a problem-solving process in which the result is reached, the result will be revised, and it will allow to be more experienced when similar problems are encountered (Basaran, 1994). In addition, with the assessment of the solution, it will be seen whether the best solution is reached or not (Bingham, 1983).

EDUCATION AND PROBLEM SOLVING SKILLS

Today, it has been a necessity for children to find solutions for daily life problems. STEM education enables children to solve problems with an interdisciplinary approach by making use of science, technology, engineering and mathematics disciplines (Bowen, 2014). For this purpose, engineering design process is taken as the basis in STEM education; because using engineering design process in education is an important way of combining STEM disciplines (King & English, 2016).

The engineering design process is the process of producing the most appropriate and necessary solutions for a problem (Basham & Marino, 2013; Capraro, Capraro & Morgan, 2013). When the definition of the engineering design process is examined from a deeper perspective, it is defined as the method of solving technological problems by using science and mathematics knowledge and the engineering skills of the engineers together (King & English, 2016). The most comprehensive engineering design process steps were formed with the study carried out by Hynes et al. (2011) by working collaboratively with the Department of Education in Massachusetts State. In this study, the engineering design process is defined as nine steps, and shown in Figure 3 (Hynes et al., 2011).

Although the engineering design process steps do not have certain limits, it is a guide to be used in education (Hynes et al., 2011). Thus, these steps can be arranged based on age groups because the main purpose of this process is to enable children to find solutions for problems (Bowen, 2014). The integration of STEM education with the engineering design process since

early ages will not only allow children to learn more in-depth, but also help teachers and children find solutions to problems by meeting their learning needs (Moore and Smith, 2014; Parker, Smith, McKinney & Laurier, 2016). Therefore, the engineering design process emerges as an integral step of STEM applications.

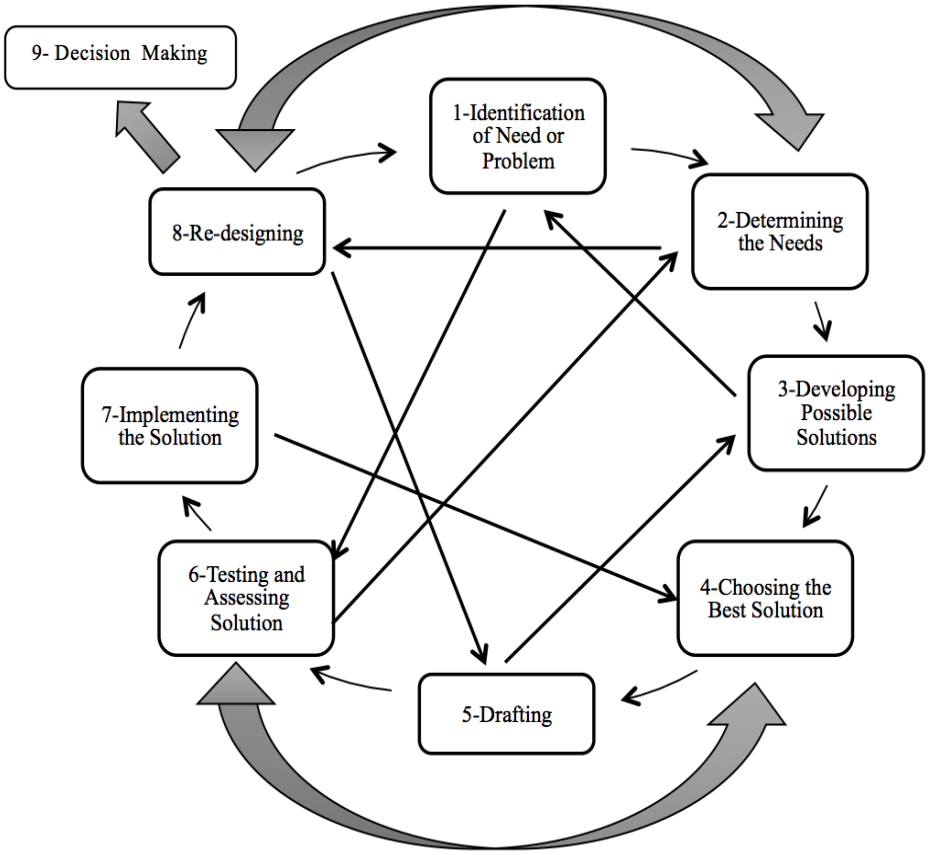

FIGURE 3. *The Engineering Design Process (Hynes et al., 2011)*

On the other hand, there is an important relation between the engineering design process and problem solving skills integrated into STEM education because, thanks to the engineering design process, children take a step to solve daily life problems by using basic mathematics and science knowledge (Basham & Marino, 2013). Therefore, the similarity of engineering design process and problem solving steps is of great importance for STEM education. In Figure 4, similar points of engineering design process and problem solving steps are given.

<table>
<tr><th>Engineering Design Process</th><th>Problem Solving Steps</th></tr>
<tr><td>Identification of Need or Problem</td><td>Noticing the problem
Explaining the problem</td></tr>
<tr><td>Determining the Needs</td><td>Collecting data about the problem</td></tr>
<tr><td>Developing Possible Solutions</td><td>Identifying possible solutions</td></tr>
<tr><td>Choosing the Best Solution</td><td rowspan="2">Applying the most appropriate solution</td></tr>
<tr><td>Drafting</td></tr>
<tr><td>Testing and Assessing Solution</td><td rowspan="4">Assessing the solution</td></tr>
<tr><td>Implementing the Solution</td></tr>
<tr><td>Redesigning</td></tr>
<tr><td>Decision making</td></tr>
</table>

FIGURE 4. *The Engineering Design Process (Hynes et al., 2011) and Problem Solving Steps*

According to Figure 4, the steps of "noticing the problem" and "identifying the problem" are similar to "identifying the need or problem" step of the engineering design process because these steps are based on understanding the causes and requirements of this situation by understanding the current situation that needs to be resolved (Bingham, 1983; Hynes et al., 2011; Sahin, 2015).

From the problem solving steps, "collecting data about the problem" overlaps with the engineering design process "determining the needs" step as the result of the aim to reach the solution by gathering the necessary information about the current problem situation (Bingham, 1983; Hynes et al., 2011).

In addition, the "identifying possible solutions" from the problem solving steps and "development of possible solutions" from the engineering design process step is similar because, with the data collected about the current situation in both steps, solution suggestions that can eliminate the current problem situation should be developed (Bingham, 1983; Hynes et al., 2011). In addition, "choosing the best solution" and " drafting" steps of the engineering design process are similar to "applying the most appropriate solution" from the problem solving steps because "applying the most appropriate solution" from the problem solving steps involves choosing the most suitable solution for the current situation and applying it for the solution (Basaran, 1994).

Finally, "assessing the solution" step from the problem solving steps involves "testing and assessing the solution", "presenting the solution", "redesigning" and "decision making" from the engineering design process. In the assessment step of the solution, whether the solution solves the existing problem or not is controlled. Thus, if any solution is not reached, it is aimed to reach the solution with necessary readjustments (Basaran, 1994; Bingham, 1983).

When the engineering design process and problem solving skills steps used in STEM education are examined, it can be emphasized that there is an indispensable relation between STEM education and problem solving skills. In addition, many studies conducted in Turkey draw attention to the relation between STEM education and problem solving skills. In order to emphasize, all the studies related to relation between STEM and problem-solving skills conducted in Turkey are shown below in Table 1. While preparing this table, the findings were

examined based on the type, year, author, purpose, method, study group of the studies, and based on STEM and problem solving skills.

Table 1. *Studies Related to Relation Between STEM and Problem-Solving Skills Conducted in Turkey*

Study - Year and Author (s)	Purpose of Study	Method and Study Group	The Findings
Doctoral Dissertation - 2019 Ayşe KOÇ	Comparison of STEM implementations with daily life materials and STEM implementations with robotic support in preschool and basic science education	Quasi Experimental Design Preschool and 5th Grade Students	STEM implementations with both daily life materials and robotic support have positive effects on students' problem solving skills.
Article – 2019 Çağrı AVAN, Cihan GÜLGÜN, Adem YILMAZ, Kamil DOĞANAY	Examination of the effects of activities based on engineering, science, astronomy and arts on students' problem solving skills, critical thinking skills, science process skills and interest in astronomy	Mixed Method 7th and 8th Grade Students	It was shown that students' problem solving skills increased significantly and positively
Article – 2019 Gülşah ÖNER, Yasemin ÖZDEM YILMAZ	Examination of the relationship between students' problem solving and enquiry learning skills that are related to STEM.	Survey 5th, 6th and 7th Grade Students	There is a positive relationship between students' STEM attitudes and their problem solving skills
Master Thesis – 2019 Muhammed Akif KURTULUŞ	Investigation of the effects of STEM-based Lego activities on students' scientific creativity, problem solving skills, STEM attitudes, motivation for learning science and academic success	Quasi Experimental Design 6th Grade Students	It is stated that STEM based Lego activities improve students' problem solving skills.
Master Thesis - 2019 Seçil ALNIAK	Examining the effects of STEM based physics education on students' problem solving skills and STEM attitudes	Quasi Experimental Design 7th Grade Students	STEM education positively affect students' problem solving skills.
Master Thesis – 2019 Zeynep DURMUŞ	Investigation of the effect of laboratory lesson based on STEM activity on self-efficacy for science teaching and problem solving skills	Experimental Design Pre-Service Primary School Teach-	It is claimed that STEM activities didn't differentiate the problem solving skills of pre-service teachers.

		ers	
Master Thesis – 2019 Tuğçe KAVAK	Investigating the effects of STEM on students' attitudes towards technology and science, scientific process and problem solving skills	Mixed Method 4th Grade Students	It is shown that STEM implementations positively affect the development of students' problem solving skills.
Master Thesis – 2019 Müzdelife KURT	Examination the effects of STEM for Science course on students' problem solving skills, academic success, attitudes towards STEM, and their interest levels in STEM	Mixed Method 6th Grade Students	STEM implementations positively affect the development of students' problem solving skills.
Master Thesis – 2019 Beyza AKÇAY	Investigation of STEM based activities effects on children's problem solving skills	Experimental Design 6 Years Old Children	STEM activities positively affect children's problem solving skills.
Master Thesis – 2019 Özge KÖNGÜL	Investigation the effects of STEM on students' science process skills and problem solving skills	Mixed Method 6th Grade Students	Science education supported by STEM positively affects students' problem solving skills.
Article – 2018 Kayahan İNCE, M. Emin MISIR, M. Ali KÜPELİ, Asuman FIRAT	Investigation the effect of activities based on STEM in teaching the enigma of the earth's crust unit on the problem solving skills and academic success of students	Quasi Experimental Design 5th Grade Students	STEM based activities have positive effect on children's problem solving skills.
Doctoral Dissertation - 2018 Dilber ACAR	Examining the effects of STEM education on students' academic success, critical thinking and problem solving skills and in science and mathematics	Mixed Method 4th Grade Students	It was claimed that STEM education was effective in developing students' non-routine problem solving skills.
Master Thesis – 2018 Sinan ÇALIŞICI	Investigation of the effects of STEM on students' scientific creativity, environmental attitudes, problem solving skills and science success	Experimental Design 8th Grade Students	It was stated that STEM implementations positively affect children's problem solving skills.
Master Thesis - 2018	Examining the pre-service teachers' cognitive structures,	Mixed Method	It is found that STEM activities improved sig-

Merve ÖZKIZILCIK	problem solving skills, STEM teaching orientations and views towards STEM	Pre-Service Science Teachers	nificantly problem solving skills of pre-service teachers.
Master Thesis - 2018 Emrah BAL	Examining the STEM activities effects on children's problem solving and science process	Experimental Design 48-72 Months Children	It was stated that STEM activities improve children's problem solving skills.
Master Thesis – 2018 Müberra NAĞAÇ	Investigation of the effects of STEM on students' academic success and problem solving skills in the teaching of "Matter and Heat" unit of Science course.	Quasi Experimental Design 6th Grade Students	It is found that STEM implementations do not have an impact on students' problem solving skills.
Master Thesis - 2018 Safiye Ceren ÖZTÜRK	The effects of STEM education on pre-service science teachers' problem solving and critical thinking skills	Mixed Method Pre-Service Science Teachers	STEM activities improve the problem solving skills of pre-service teachers.
Doctoral Dissertation - 2017 Canay PEKBAY	Investigation of STEM based activities effects on students' problem solving skills based on daily life, interest in STEM and views about STEM	Mixed Method 7th Grade Students	It was claimed that STEM activities positively affect students' problem solving skills based on daily life.
Master Thesis – 2014 Sevil CEYLAN	Investigation of the effects of acid and bases in STEM based science course on students' problem solving skills and academic achievement	Experimental Design 8th Grade Students	STEM based program has positive effect on problem solving skills of students

DISCUSSION and CONCLUSIONS

The developing economy and technology have also enabled many differentiation and development in education. Especially in the 21st century, these developments paved the way for interdisciplinary approaches in education and revealed its importance. STEM approach is the most striking interdisciplinary approach today. In addition to being an interdisciplinary approach that includes the disciplines of mathematics, engineering, technology and science, STEM also contributes greatly to the development of individuals' 21st century skills like problem solving, creativity and critical thinking. Especially, there is a striking relationship between STEM and problem solving skills. In the literature, the relation between STEM education and problem solving skills is an important subject. When the engineering design process and problem solving steps used in STEM education are examined, it is seen that there is a similarity. At this point, the engineering design process supports the problem solving steps, and so positively affects children's problem solving skills. For this reason, the relationship between STEM and

problem solving skills is becoming increasingly important.

When the literature is examined, it is seen that besides the relationship between STEM and problem solving skills, the positive effects of this relationship are supported by many academic studies. As seen in Table 5, the studies on STEM and problem solving skills have gained importance especially in the last six years in Turkey. In the last two years, the studies have gradually increased, and the groups at different levels of education are studied with. Three of the nineteen studies are doctoral dissertation, three of them are articles, and thirteen are master's theses. Two of these studies were carried out with students in preschool education, two with primary school, eleven with secondary school and three with university students. In addition, a study was carried out with both pre-school and middle school students. One of the studies was carried out as survey, eight mixed, and ten experimental design methods. The results of the studies support the contribution of STEM education to problem solving skills. In seventeen of the nineteen studies, it was resulted that STEM or STEM-based activities contributed positively to children' / students' / pre-service teachers' problem solving skills development. Only two studies reported that STEM activities did not make any difference in problem solving skills. As a result, it is seen that the relation between STEM and problem solving skills mentioned in the literature is supported by the studies.

Studies conducted to examine the relationship between STEM and problem-solving skills support researchers' hypotheses. In this respect, it is seen that the problem solving skills, which are one of the basic skills of education, whose foundations were laid in the early years, can be supported and developed with STEM Education. On the other hand, although the foundations of this skill are laid in the early years, studies on STEM and problem solving skills are mostly carried out at the secondary education level. However, problem-solving skills need to be acquired in the early years because problem solving is a life-long skill starting from birth. Therefore, the sooner children encounter problems, the sooner their problem-solving skills will begin to develop. The greatest contribution to this development will be through the integration of STEM into educational programs.

When all these results are examined, the following suggestions are made;

• STEM activities and learning outcomes should be integrated into all levels of education. Thus, it can be supported to educate individuals with 21st century skills, especially with problem solving skills.

• Education programs and seminars can be organized for all educators to implement and disseminate STEM education; which might lead the changes to proceed more permanently and quickly.

• Considering the importance of STEM education at all levels of education, teachers who are ready for innovation can be educated by adding STEM related lessons to the teacher training programs of universities.

• Finally, it should not be forgotten that STEM education has a positive impact, and STEM education might be emphasized in education. To make this emphasis, the studies on STEM education might be increased at all levels of education.

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