THE UNKNOWN TERRITORY OF STEM: THE PERCEPTIONS OF HIGH SCHOOL ADMINISTRATORS

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Approval of the Graduate School of Social Sciences

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ABSTRACT

THE UNKNOWN TERRITORY OF STEM: THE PERCEPTIONS OF HIGH SCHOOL ADMINISTRATORS

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Science, technology, engineering and mathematics (STEM) education is an educational approach gained importance in the last decade and became a trendy topic among the educators, policy makers and academicians beginning in the United States of America and spread all over the world. The aim of this study is to investigate the perception of school principals about STEM education who are working in the prominent high schools in the Ankara province in Turkey. The sample is selected from three different school types that are Science High School, Anatolian High School and Anatolian Imam and Preacher High School. In order to understand the perception, experience and role of the school principals regarding STEM education, phenomenology as qualitative inquiry method was used and semi structured interviews were conducted with eleven school principals. For the triangulation of the study, document analysis was carried out. After the data analysis, nine themes emerged under three research questions investigating the perception, experience and role of the school principals. The results of the study showed that there is lack of knowledge, readiness and physical environment as an obstacle towards the implementation of STEM education in those schools. When the results of the study are considered, the implementation of STEM education requires the improvement of physical

infrastructure as well as professional development for both teachers and school principals regarding the implementation of STEM education. Yet, there is lack of teacher educators in interdisciplinary sense to prepare teachers for STEM education. Therefore, this policy borrowing issue should be considered again.

Keywords: STEM education, educational policy, school principals, high school education

ÖZ

STEM EĞİTİMİNDE BİLİNMEYEN ALAN: OKUL YÖNETİCİLERİNİN STEM EĞİTİMİ HAKKINDAKİ GÖRÜŞLERİ

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Bilim, teknoloji, mühendislik ve matematik (BİLTEMM/STEM) eğitimi son on yılda önem kazanan; eğitimciler, politika geliştiriciler ve akademisyenler arasında popüler olmuş ve Amerika Birleşik Devletleri'nden dünyaya yayılmış bir eğitim hareketidir. Bu çalışmanın amacı Ankara'nın ve hatta Türkiye'nin önde gelen liselerinde görev yapan okul müdürlerinin BİLTEMM ile ilgili algılarını araştırmaktır. Çalışmanın örneklemi üç lise tipinden seçilmiştir. Bunlar; fen lisesi, Anadolu lisesi ve Anadolu imam hatip lisesidir. Müdürlerin BİLTEMM konusundaki algılarını, deneyimlerini ve rollerini anlamak için nitel araştırma deseni olan fenomenoloji kullanılmış ve on bir okul müdürüyle yarı yapılandırılmış görüşmeler yapılmıştır. Çalışmada çeşitlemeyi sağlamak için görüşmenin yanında doküman analizi metodu kullanılmıştır. Veri analizi sonucunda okul müdürlerinin BİLTEMM ile ilgili algıları, deneyimleri ve rolleriyle ilgili toplam dokuz tema ortaya çıkmıştır. Çalışmanın sonucunda varılan sonuç; okullarda bilgi, hazırbulunuşluk ve fiziksel yapı açılarından eksiklikler olduğu ve bu eksikliklerin BİLTEMM eğitimini uygulamada engeller oluşturduğudur. Araştırmanın sonuçları göz önünde bulundurulduğunda, BİLTEMM eğitiminin uygulanması için fiziksel altyapının geliştirilmesinin yanında hem öğretmenlere hem de okul müdürlerine hizmet içi eğitim verilmesi gerekmektedir. Ancak, öğretmenleri

BİLTEMM eğitimine hazırlamak için gerekli olan interdisipliner yaklaşımla öğretmen yetiştiren eğitimcilerin eksikliği söz konusudur. Tüm bunlar düşünüldüğünde, BİLTEMM eğitiminin Türkiye'ye bir politika ithali olarak getirilmesi konusu tekrar gözden geçirilmelidir.

Anahtar Kelimeler: BİLTEMM/STEM eğitimi, eğitim politikası, okul müdürleri, ortaöğretim eğitimi

To My Beloved Family

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

STEM	Science Technology Engineering Mathematics
MoNE	Ministry of National Education
TES	Turkish Educational System

CHAPTER 1

INTRODUCTION

1.1 Background to the Study

The conception of education varies according to the philosophies, notions, the vision of world, and personal experiences of an individual so that there is no common definition or conception for education; however, in a broad sense it can be said that education is the "total social processes that brings a person into cultural life" (Gutek, 2009, p.7). While Einstein saw education as the remaining parts from what it was learnt in schools (1931), Dewey sees it not as "a preparation for life but the life itself" (1916, p. 239). Description of education is freedom for Freire (1976) and replacing an empty mind with an open mind for Forbes (UK Essays, 2018). Where Kant states education is a way to develop all the perfection in oneself which the one is capable of (Kanz, 1993), Bloom indicates that it is a movement from darkness through light (Durkheim, 2006; Price-Mitchell, 2014). There is no consensus on this educational definition in philosophers, educators, sociologists or politicians since it is based on the philosophy they follow, their vision of world, and their experiences. This variability is also valid for the functions of education.

Different understandings of education indicate different functions of education and the main focus for those functions/goals is different from each other. According to the literature five different functions of education are determined as social, political, cultural, individual development and economic function (Duckworth, 1964; Durkheim,2006; Hanushek, 2011; Saltmarch,1996; UNESCO, 1992). The social function of the education is to provide and sustain the equilibrium in the society by preparing the generations who are not ready for the social life by adult generations to fit the moral, intellectual and physical states preferred. The social facts as law, moral

regulations, norms and values and institutions like school, family, NGO, and financial institutions are the main parts maintaining the society. The “school” institution is the miniature of the society and the socialization is the key function in education with three others as social integration, social placement and social and cultural innovation (Ballentine & Hammack, 2015; Durkheim, 2006).

Apart from the social function of the education, there is a political function which aims to raise generations by the thought of democracy, community service, inquiry, individual engagement to the society and social transformation through the education which is not the means of living life but the life itself according to Dewey (Saltmarsh, 1996). While education is for the reconstruction and renewal of the experiences for Dewey (Beckett, 2018), for Freire, education is for increasing the ability to ask right questions which is inherited in the human kind to be curious about what is happening and through this way raise the liberation of not just the students but also the teachers as co-investigators (Beckett, 2018; Freire, 1992). That is how the community life and social sustainability would be confirmed.

Cultural function of education is about to be part of the society by learning the “spiritual, material, intellectual and emotional features” of the society through education. To broaden the horizon, learn the other culture and respect them are other necessities of cultural development (UNESCO, 1992).

In addition to those functions there is individual development function of education which is about the intellectual development of individuals. Jean Piaget, the psychologist, states that every child has the capability of evolving intellectually with three main processes of action in mind as accommodation, assimilation and equilibrium (Piaget & Cook, 1952) which is basically about the understanding and interpretation of a phenomenon through those processes. According to Piagetian inspired curricula, in this intellectual growth, the teacher has the role of guiding the way of learner in the process of discovery (Ginn, n.d). Therefore, the other educational role of the education is to provide the intellectual development of the individuals for raising generations who have the ability of doing new things (Duckworth, 1964).

In a society the role of institutions is about human interaction where the consequences created by those institutions are in terms of political, social and economic (North, 1990, p.3). The economic growth depends on the economic institutions where the important part of this growth is about the human capital (Acemoglu, Johnson & Robinson, 2005; Becker, 2018). Human capital is about the investments of individuals in education, training and health mostly since skills, knowledge, health conditions are not separated from the individual himself (Becker, 1964; Becker, 2018). Therefore, people invest in human capital by gathering skills, developing abilities that later have outcomes which matter for their life spending (Hanushek, 2011). For those reasons, education and schools have an important role in economic growth of states and the development of countries. High quality education is needed for long run growth in economic development since the workers' cognitive skills and the income level related to their skills and knowledge matter for this growth (Hanushek, 2018). Although experiences in a school year are assumed to be the same but it is not, the quality differences affect the productivity and national growth rates. Thus, public policies and policy making gain importance to improve schooling and education (Hanushek, 2010, Hanushek, 2018).

As this is the case, in order to help the ratchet keep going without any pause, reform is essential in schools and in educational practices to fit this technological age and developments for participants of schools as school principals, teachers and students for innovative generations (Cuban, 2001). The ratchet here is the change in technology having a pawl that push it to grow apace but no going back. Since the world is changing and evolving with new technologies and developments from the industry to health sector and many others affecting every small piece of the lives, it is not possible to think whether it takes a role in education or not. It has impact on how we learn as the time changes and technology develops. There are movements of policy making for trying new educational approaches in education to catch the necessities of the living era for economic growth. Therefore, Science Technology Engineering and Mathematics (STEM) education is an educational trend in this era with its interdisciplinary learning approach which has been launched since innovation, technology, scientific literacy earned significant importance for countries to take a place in global economy (Baran, Bilici, Mesutoglu & Ocak, 2016). On the contrary to

the general notion that "Starting point of STEM education was education", the starting point of STEM was economy (Öztürk,2018). This trend was spread to all over the world for K-12 level. Those levels, according to Mihelich, Sarathchandra, Hormel, Storrs & Wiest (2016) has effect on the development of the interaction with science for most adults as the human capital of the people affects the technological development of countries as well as the economy (Becker, 2018). Research has emphasized that in the digital age we live, the school improvement does not occur unless the type of industrialized schooling is abandoned since it does not meet the needs of today's learners (Alberta Education, Friesen & Jardine, Jacobs, Kaplan & Owings, & Sawyer as cited in Brown & Jacobsen, 2016). Therefore, STEM education is seen as a tool to meet those needs as long as they are integrated to the educational practices in K-12 level. However, it necessitates reform in schools and in educational practices to fit this technological age and knowledge era for participants of schools as school principals, teachers and students for innovative generations (Cuban, 2001) by discussing the STEM issue over a decade. Yet, this is a controversial issue whether STEM education is the approach including the educational practices for the improvement of schools and raise of the innovative generations.

After the launch of STEM education in the United States of America, it created a stir globally and it was attempted to be tried in countries without any theoretical framework or epistemological base. This makes the STEM education a policy borrowing issue for countries. As indicated by Nir, Kondakci and Emil (2018), the policy borrowing should be done by following an integration process for the policy borrowed so that the implementation of the borrowed policy could be successful in another context as its own. In order to do that there is a need of the collaboration of universities and MoNE. However, those institutes have independent political implementations about STEM education preventing a national level policy development including all stakeholders of the educational system in Turkey. Therefore, the question arise from that issue is that is it necessary to implement STEM education in Turkey? The rise of the question is not just because of the policy borrowing issue, but also because of the lack of knowledge and the infrastructure as well as the organizational culture (Kondakci & Kulakoglu, 2018). In order to resolve the lack of knowledge issue of school principals and teachers, the professional

development for them was indicated in the literature. When Chai (2019) investigated twenty studies related to the teacher development for STEM education, the lack of theoretical and epistemic framework for the teacher training is found. Also according to the study Havice, Havice, Waugaman and Walker (2018), there is still gap in the literature about how the teaching profession could be improved regarding teaching skills and concepts according to integrative STEM education "in all experience levels". Therefore, although the indication of teachers' need of professional development in the literature, there are gaps arising from the lack of epistemic and theoretical frameworks for those trainings. This gap is also valid for the STEM educational practices in the schools since there is an uncertainty regarding what STEM could be and how STEM disciplines could be integrated (Kloser, Wilsey, Twohy & Immonen, 2018). That is why STEM education is seen as a fuzzy movement showing it as a trendy approach rather than a concrete educational need. Thus, STEM education is an issue to be considered with all the aspects beginning with forming the epistemological base if the integration of STEM education is a necessity in the educational context.

Apart from lack of epistemological framework and policy borrowing issue about STEM education, the importance of the leadership for the implementation of this kind of integrative teaching learning environment is also ignored. For organizational change and development through the direction of the integration of new implementations, there is a role that should be assigned to school principals. School principals are the leaders who need to have the expert power to lead the school implementations and processes by their knowledge and expertise (Hoy and Miskel, 1987). The importance of expert power for leading the way in the process of STEM education is inevitable as well. therefore, the issue of STEM education should be investigated from the perspective of school principals in order to understand their perceptions and their possible roles in STEM education.

1.2 Purpose of the Study

The reputation of STEM education occurred in Turkey by the footsteps of academicians coming back from the United States of America in the time STEM education spread over the country and they make some academic and field work. Then this trend has been applied especially into the academy and private schools

(Ozturk,2018). After those implementations in private schools and academy, this trend began to spread out to Turkey and STEM education became an education trend taking place in national education as indicated by the 2016 STEM Report of Ministry of National Education as a state policy (Ministry of National Education,2016). In this report it is indicated that there is no action plan for the application of STEM education but there are some goals stated in 2015-2019 Ministry of National Education strategic plan. In the same plan, the lack of studies and projects done by universities was pointed out (Ministry of National Education,2016). As well as the research in global world, this educational trend has subjected to the studies in Turkey and according to Cevik (2017), in Turkey, between the years of 2014 and 2016, 34 articles were published in the area of STEM education which is mostly investigated from the perspectives of STEM evaluation, engineering, science, STEM opinion and STEM tendency of mostly candidate teachers, students and rarely teachers. On the contrary, there is no study gathering data from school principals or administrators for the STEM studies in Turkey as a reflection of the lack of studies in global research area about this topic.

Although STEM education is a trend topic for the academic studies, there is a lack of studies centering on the school principals globally and there is no study regarding the school principal perspective about STEM education. Key constituencies are not skilled to grasp STEM as the practice itself has not been elucidated yet. Besides, the infrastructure needed for STEM in Turkish schools is not adequate yet. Thus, the futile practices around STEM make it look like a fad, just like many other travelling policies or policies borrowed from Western countries. Turkish governments and private schools seem to be generous in investing in STEM without assessing the relevance of STEM into Turkish education system.

Particularly leadership plays a specific role in situating, implementing and realizing change and development in TES (Kondakci et al, 2019). As in the case of many other change interventions, STEM practices need to be assessed from leadership perspective.

Therefore, the purpose of this study is to understand the notions and perspectives of the school principals working in the high schools named as project schools applying special program or taking students with standardized, centralized examination in

Ankara district. By this way, STEM education procedure in Turkish high schools will be examined through the eyes of the administrators of schools. For this purpose, the interviews are conducted with school principals. For the interview protocol, the questions are prepared according to the detailed framework formed by NYC Department of Education with the name of NYC STEM framework having four main domains as (i) school vision and structure for success, (ii) STEM curriculum instruction and assessment, (iii) strategic partnership and (iv) STEM college and career readiness which includes planning and preparations for K-12 level. Those four domains have different subdomains as well. This framework was chosen as the base for the interview protocol since it approaches STEM education from perspectives having relations with the administration side of the STEM education. By having this basic framework touching upon the important aspects of STEM education needs for the implementation in the schools, the aim of the study is to find out the perceptions of school principals regrading STEM education. For this purpose, three research questions are formed and the research questions of the study are:

1. How do the school administrators in high schools perceive the educational trend of 2010s "STEM education"?

2. What are the experiences of school administrators in STEM practices?

3. How do school administrators define their roles in STEM practices at their schools?

1.3 Significance of the Study

The current study intends to make contribution to theory, practice and research in educational administration. As to the theory, there is a broad discussion on STEM. However, most of these studies focus on the topic as a field of practice and do not propose a sound theoretical background to guide the practice.

First, getting the perceptions of school principals about STEM education will contribute to understand where they are standing as an administrator leading this trend in their schools. In that sense, the study captures the gaps in conception and implementation of STEM education in Turkish schools from the educational

administration perspective. This contribution is significant because of the ministerial report which sets some goals for STEM education for four years of national education strategic plan and indicates the lack of studies about this educational trend (Ministry of National Education, 2016). This study aims to understand how current form of practice in STEM education lacks a policy framework for an effective implementation by approaching the issue from the perspective of educational administration.

In the literature, there is a lack for the understanding for school principals' role in STEM education on the contrary of several indications of students and teachers and even the parents' perceptions about this trend and teachers' role in STEM education. STEM education has been investigated including perception of students towards STEM in many studies for the need of sustainable and confirmed place in global economy in the age of innovation (Kelly, 2010). Also perception of teachers who have been mostly attributed as the ones having importance with their perception, knowledge and preparedness about STEM (Corlu, Capraro & Capraro, 2014; Bell, 2016) and even the perception of parents are examined by looking at the relationship between the perception of parents and the attitudes of their children towards STEM and science education (Mihelich et. al., 2016). Therefore, by this study, the importance of the school principals' role for a new trend, STEM education, are identified as a leader or administrative in teaching and learning environment by arousing the teachers, and encouraging them to be the part of the innovative moves and applications of new trend STEM education because although there are studies about leadership of school principals and innovation in school culture (Khalid, Madeeha & Amna, 2011), the role and perception of school principals about STEM education is a new area not studied in the literature. Therefore, this study contributes to the theory from the perspective of leadership/administration in relation to STEM education by adding a new dimension to innovative educational approaches and school principals' administration.

Additionally, there is a significance of the study for the method. As methodology, this study is designed to be qualitative which is for the deep understanding of a concept. The main data collection tool for this purpose is interview to understand the general perception of school principals about the STEM education, its application and its importance for their schools. For this purpose, the interview questions were formed by

considering the main domains of STEM framework (NYU Department of Education, n.d.) and by taking expert opinion. Thus, this study's contribution to the method is the interview questions formed by taking the role of school principals in schools into account. These interview questions could be a base for further studies investigating the issue with mixed method and quantitative method studies. Also, questionnaires could be developed from those interview questions to understand the issue in wider perspective. In addition, the current study shows the importance of investigating STEM education from the perspective of teachers, principals and even the principals in relation to educational administration.

On the whole, the significance of the study from the perspectives of practice, theory and method show the contributions to the literature of this study in the area of educational administration and planning.

1.4 Definition of Terms

STEM Education: will be accepted as the integrated whole where all four disciplines i.e. science (S), technology (T), engineering (E), and mathematics (M) taught and learnt together rather than approaching them as four separate disciplines in this study.

School Administration: carry out (a) research and planning, (b) organization, (c) guidance, (d) tracking, supervision and evaluation and (e) communication and governance works in the school.

School principal: is the head of the school who implements the regulations of Ministry of National Education and s/he is the regulator of the instructional processes by investigating the annual plans for the curriculum implementation prepared by teacher community in same branches (Ministry of National Education 2016).

School Vice Principal: is responsible to the school principal for regulating the educational and institutional processes (Ministry of National Education 2016).

Perception: "The way in which something is regarded, understood, or interpreted" ("perception", n.d)

CHAPTER 2

LITERATURE REVIEW

2.1. Emergence of STEM education in the United States of America

Development in technology has changed the way we use technology in education fundamentally. Particularly ICT has had a drastic impact on education over the last two decades. Failing education systems is a basic concern for every nation. For the case of the United States of America, the concern over the failing educational systems has been a top issue on the agenda of different governments. Although its popularity raised in the 2000s, the roots of STEM education are based on the times the Sputnik has been launched. When the times Soviet Russia has been prepared to launch Sputnik to the orbit, in 1950s, the United States of America was taking steps in education to avoid the change in the place of the United States of America as an economic power and STEM based superiority (Bybee, 2013, p.13). After those times, the United States of America made educational policies about the science teaching to encourage the young to be part of STEM careers at various times as in "Nation at Risk" (1983), "Rise Against Gathering Storm" (2008), and "Educate to Innovate" (2009).

The seminal report of "A Nation at Risk" mention high retention, lack of achievement in international educational comparisons, the high costs spent to training of basic skills as reading, writing, spelling and computation (Gardner, 1983). The complain about the decline of achievement in mathematics, science and literature in comparison to the times of the launch of Sputnik has been also stated in the same report. Twenty-five years after this report, another report has been written related to approximately same concerns but including more indication of the science and technology especially the information technology which was Rise Against Gathering Storm by the United States

of America government about the concerns of economists, policy makers and educators (Augustine, 2008). The evolution of the time through the technology made the innovation and science the number one priority to have a special place in the global market to make countries' marks in the world not just in economic base but also as a social and political power to represent the global authority. As stated in the latter report, the dependence of right to have a comment on the economy globally, even before the revolution of information technology, was related to keeping the pace with the technological changes and development. Another issue concerning the United States of America government was the thought of possible decline in the "high standard living" because of staying behind in STEM areas (Augustine, 2008). While this is the case, in the age of "Death of Distance" thanks to the computerized actions and the clicks to reach all over the world, the leading through technological advancement is inevitable. Thus, the United States of America had the concerns about losing the lead in the technological and scientific developments representing the power and they indicate those concerns as to satisfy the human capital needed for the future of economy and to meet the national needs as supplying affordable and clean energy via technological developments and some recommendation to prevent this loss or satisfaction of those needs. The recommendations included such comments on having raise of price for science and mathematics teachers, keeping students in the pipeline of STEM education from the beginning of their education to choose a career in the field of STEM (Ball, Huang, Cotton & Rikard, 2017), training in-service teachers to have the ability to reach students about those fields, giving scholarships to students to choose a career in STEM fields (Augustine, 2008).

The main raise of the STEM movement took place after the acronym of STEM education was initiated replaced by SMET to get rid of the confusion with the word of "smut" (Sanders, 2009). The acronym is created by Dr. Judith Ramaley (Chute, 2009) as STEM to define science, technology, engineering and mathematics in 2001. The meta analysis conducted by Banning and Folkestad (2012) about the written dissertations in the subject of "STEM" for the years beginning with 1990 to 2010 showed that there is no dissertation about STEM education between the years of 1990 and 2000. In 2001, two dissertations containing the subject of STEM were written. Therefore, this educational trend gained importance in the new century. By the 21st

century, the world evolved where technological advancement, innovation, critical thinking, problem solving, creativity, scientific improvements and engineering based studies take the lead to be part of the global world. That is why STEM education idea was revealed by the United States of America to be the leading actor of those actions. On November 23rd of 2009, president of the United States of America of that day, Barack Obama, launched the campaign of "Educate to Innovate" which is initiated for the global concerns of the United States of America as to be the head of the economic power and scientific improvements. The launch of the movement "Educate to Innovate" representing the educational focus on STEM Education named by the initials of Science, Technology, Engineering and Mathematics (STEM) Education aimed to have literate students who choose career in the path of STEM for meeting the challenges of the 21st century and provide solutions for the national needs as cures for diseases, preventing the dependency of fuel oil and finding affordable and clean sources of energy (Office of Press Secretary, 2009). To get the attention of the students to STEM education the funding was launched, scholarships were created and the need for technological development was stated for the future (Office of Press Secretary, 2009). The idea behind this project is to compete with the countries as China and India in the global economy area because of the thought that they are taking the lead in economy (Ozturk, 2017).

The concerns about taking lead in science and technology is not just about economy but is also related to the doctorate graduate rates from the United States of America universities. The graduates between 33% and 50% are from the foreign born –non-native- students who are mostly from the Asian origins and they prefer not to stay the United States of America and go back to their home town. That is to say, they do not choose to be the part of the United States of America growth (Valerio, 2014, p.111). Those reasons and also the enthusiasm to be the producer of the technology and science rather than the consumer as a nation make the United States of America government take steps in these areas. (Office of Press Secretary, 2009). Therefore, this is basically the history of STEM education. After those times leading the beginning of STEM education this educational approach spread all around world and become global idea to be satisfied and the applications in educational systems brought both pros and cons.

From now on, they will be presented to approach the STEM education from different perspectives helping to make clear understanding about it.

2.2. Emergence of STEM education in Turkey

After the launch of Educate to Innovate campaign which is seen as the actual rise of STEM education in the United States of America, STEM education affected educational practices globally. As it created stir globally, it had reflection in Turkey as well. The emergence of STEM education began with the return of individuals to Turkey done their PhD in the United States of America after 2009. Those individuals worked in the universities' STEM centers in the United States of America during their PhD or postdoc experiences. Then, they wanted to move the idea of STEM education into their own country which they consider effective for the educational practices in Turkey by transferring their knowledge gained in there. In this process, the academic research done in Turkey about STEM education to integrate STEM education practices into Turkish educational context. The collaboration of academy and the schools for STEM education practices resulted in the formation of different size of groups working on the implementation of STEM education in Turkish context (Ozturk, 2018). Starting with the private schools, they spread the idea of STEM education which then became an advertisement tool for those private schools to attract attention of students and their parents. After the country familiarized with the STEM education by those actions, MoNE published the report "STEM Education Report" in 2016 to spread the idea to public schools as well. The report includes both the advantages of STEM education and the obstacles against the implementation of STEM education such as the need for the rearrangement of the science classes and supplementation of the experiment materials, teacher development needs, curriculum change for the integration of STEM education. MoNE also brought suggestions for how STEM education could be integrated into schools (2016) In addition to those, the necessity of STEM education in this era for all countries has been emphasized because of the knowledge based society needs rather than the labor power in the report. Also, STEM related practices of all countries has been indicated by stating the STEM education and its contribution to economic power of the countries (MoNE, 2016).

After the reveal of this report, YEĞİTEK (Innovation and Educational Technologies Head Office which is a division under MoNE) published another report in 2018 which was the hand book for teachers for the implementation of STEM education. In that handbook, the indication of the existence o STEM education in our school has been done. Also expensive experimental materials and technological facilities are unnecessary as it has been indicated in the hand book. Apart from this, the project based learning and the STEM education relation has been stated by YEĞİTEK to the teachers in order to provide their usage of the project based practices in their classes for the STEM educational implementations. (2018)

2.3 Definitions of STEM Education

STEM is a controversial educational subject not just with its non-agreed definitions but also with policy and purpose issues (Garibay, 2015). Apart from the debates about policy and purpose issues, definition is the basic as stated by English (2016) that the issue about the integration of STEM education is the different descriptions and perceptions researchers and curriculum developers have. That is why they refer to different interpretations when they state different STEM definitions. Vasquez (2015) organized the general educational teaching approach to STEM in a paper representing four basic definitions for STEM to be used by researchers and practitioners (teachers, curriculum developers) which are represented in Table 2.1. The confusion about the definition of STEM is stated in different research indicating that the STEM is not understood in a common way since there are some practitioners as principals, policy makers, and teachers some of whom see it as an acronym of four distinct subjects and some consider it as an integrated curriculum where STEM is understood as a replacement of teaching methods from traditional ones to problem based learning through the curricula it is based on (Brown, Brown, Reardon, Merrill, 2011; Breiner , Harkness, Johnson, Koehler, 2012) where Vasquez (2015) indicated that STEM is not a curriculum.

The other issue about the definition of STEM education is about how it is applied in elementary, secondary and higher education levels. In K-6 levels STEM is about the learning of science and mathematics only where in 8-12 levels it is as the same as K-6 but additionally there are selective courses representing the technological,

Table 2.1

The common definitions referred in different STEM integrations (adapted from Vasquez (2015, p.13)

The integration form	The characteristics of that form of integration
Disciplinary	The learning occurs separately for STEM disciplines indicating an acronym
Multidisciplinary	The learning occurs separately for STEM disciplines but in a common theme
Interdisciplinary	The learning occurs by the interdependency of two or more disciplines in STEM acronym to deepen the knowledge and skills
Transdisciplinary	The learning occurs by the real world problems or projects implemented in the light of the interdependency of two or more disciplines to shape the learning experience

based sides and innovative thinking of students. In undergraduate and graduate level, the courses are split into two as STEM and non-STEM courses (As cited in Xie, Fang, Shauman, 2015). Those differences also bring about the diversity to the description of STEM. Moreover, the diversity of the description of STEM education results in the confusion of all how to be prepared to STEM education. Because of the fact that new approaches and new systems need organized and well-planned policies, the states should take careful steps towards the definition and application of the STEM education before accepting it as an educational approach. The curriculum and practices in schools take form according to the philosophical and sociological perspective of policy making so it is necessary to agree on something in common for a state to have coherence. That brings the issue of policy borrowing and policy making issue to the light.

2.4 STEM Pipeline

The interaction with science is developed in K-12 level for the individuals and there are several factors affecting their attitude towards science as parent orientation towards science, social and demographic constructs (Mihelich et al., 2016).

Therefore, since the career choice of next generations in the STEM field is seen important for the development and stability of countries in innovative and scientific areas, increasing the possibility for career path in these fields brought the idea of STEM pipeline. It is a metaphor representing that the students who are in the education life will be taught in the way of STEM along their education life time in order to increase the possibility of their career choice in the STEM areas at the end of their education (Ball, et.al., 2017). The basic idea behind the pipeline is about closing the skills gap in STEM areas revealed because of concerns appeared for the economic reasons. To be able to close the gap as indicated, STEM pipeline seems necessary. However, according to Mendick, Berge and Danielson (2017), the rationale provided for STEM pipeline as a skills gap is not as it is told. There is a contradiction between the policy makers' arguments and the actual numbers. As Mathis (2011) stated, there is no lack of high quality employees since there are three times more applicants for the jobs requiring high quality employee candidates where the high quality job refers to the ones including areas of STEM. On the contrary, the problem is about the lack of high quality jobs offered for those having the capability and the necessary skills for the qualified jobs. That is why there is a contradiction as there is no skills gap (Mendick, et.al.,2017).

The issue about STEM pipeline is that this pipeline leaks the students at some points who do not choose to be the part of the pipeline. According to Cannady, Greenwald and Harris (2014), STEM pipeline term is used mostly to prevent the leak but not mention those who choose to be the part of STEM fields. Therefore, in the literature, pipeline studies are mostly about leaky STEM pipeline which loses the students in certain levels and how to prevent the loss. The idea behind this notion is that the ones who already have the interest, passion and talent to STEM fields are already in the STEM fields on the contrary of those who are not interested to those fields. The necessity to involve those uninterested into STEM fields because of economic concerns forms the basis of STEM pipeline (Magnuson, 2018). The dropout from the pipeline is investigated mostly about the underrepresented minorities and women because the common though about it is the lack of participation of women and minorities to the STEM fields as a career path (Bergeron & Gordon, 2017).

The STEM participation of the women was studied by looking at the courses men and women take from STEM fields to decide on who are in the STEM pipeline and it was seen that the women in those courses are less than those men taking the course on the contrary of the statistically non different performance they make (Bergeron & Gordon, 2017). However according to Cannady et. al. (2014), taking the courses or bachelor degrees to label who are interested in STEM education and take career in STEM fields does not actually represent who works in those fields since the ones having bachelor degree different from STEM fields could work in STEM fields. Therefore, STEM pipeline is an educational path desired for children to be in it through the way of career choice in order to be involved in the work force in STEM fields.

2.5 STEM as a Policy Issue

STEM education is addressed from three different viewpoints as a pedagogical approach, a political approach and a popular educational subject (Asik, Doganca Kucuk, Helvaci & Corlu, 2017). In addition to the investigation of teachers' pedagogical knowledge to implement STEM education, many studies suggested teacher training to implement STEM education (Brown, et.al, 2011; Cevik and Ozgunay, 2018; Chai, 2019). According to the Chai (2019)'s review of 20 studies about teacher development from the perspective of content, pedagogy and technological issues (TPACK), the results showed that although there is a need for teacher professional development regarding STEM education implementation, there is lack of concrete base and theoretical framework for the formation of this kind of professional development materials as well as the lack of teacher educators teaching the way of teaching in the interdisciplinary sense.

Apart from the pedagogical approach, there is a political approach towards STEM stating its policy issues. As stated by Atkinson (2012) pushing every individual to be in the STEM disciplines is like pushing everyone to play piano without an interest. This is because of the economic returns of STEM education because of the age we live. Xie, et.al. (2015) stated that in the economic literature, education is seen as the human capital investment which has economic returns and STEM education is the way of more economic returns. Although this is the case, Mathis (2011), pointed out the

fact that the STEM education could be useful in this time, yet twenty years later the importance of STEM education could shift to another direction. Therefore, there is a need for diversity in the educational environment as well as the professional life for individuals to participate and the rationale behind STEM education is not reasonable for that reason. This is how STEM education is perceived from the perspective of policy issue.

Another perspective towards STEM education is approaching it as a popular educational subject and in those perspectives the most commonly preferred one is taking STEM in consideration as a trend. Therefore, Hoeg and Bencze (2017) raised the question "STEM as a 'golden opportunity' or a 'Trojan horse'?", indicating the dilemma whether it can be useful for the countries' improvement or not. This concern reveals because of the fact that the formation of the STEM educational practices without any planed and organized policy support (Hoeg & Bencze, 2017) is seen in many countries coming up with the popularity of STEM education. On the contrary of its popularity, the quick decisions on the idea of integrating this trend to the educational systems do not make miracles.

The main idea behind the educational reforms should be giving consideration on the factors affecting the educational system of a country. Rather, the decisions are made by policy makers and governments fitting right place in the right time to appear with a policy change because of the created pressure by media through the usage of "shocking results" and "failures" in international competition based evaluations done by organizations as OECD like PISA (Baird, Johnson, Hopfenbeck, Isaacs, Sprague, Stobart & Yu,2016; Grek, 2009; Steiner-Khamsi, 2004, p.208). This is what happens in the integration of STEM education as well. Because of the economic concerns and the competitive nature of global market to have a place in, countries make changes and policy differentiation causing the convergence of educational applications all over the world (Baird, et. al., 2016). The convergence in educational systems in globally changed world as a result of policy makers' approach to making policy as a borrowing issue without giving any comprehensive thought on the policy issue. The policy making is seen as integrating the "successful" ideas and educational practices in other countries to their own country. However, according to the book "Finish lessons" by

Sahlberg (2011; as cited in Sellar & Lingard, 2013), the reason of the success or failure of the educational systems does not depend on just one factor but there is a comprehensive package to think about while making policy changing formed by educational, political and cultural factors. On the contrary of what needs to be done for the improvement of education in the country based on their cultural and societal needs, the choice about policy making is done in the direction of educational convergence globally.

According to Mathis (2011), every country has its own priority in the market place but it is neglected by policy makers. Policy makers take action according to the common sense and personal experience, those movements made are also based on the global policy making trends as assessments triggering international competitiveness and the need of work force (Plank, 2011; Rappleye, 2009). The STEM movement is also the result of this policy action spread all over the world from US showing an exemplary educational convergence and sudden integration of STEM education to the states' policies. However, as Mathis (2011) indicated that whether the world will need STEM in the future is a questionable situation for the next 20 years, trying to educate all individuals in those areas will not raise the diversity in work force. Also, assuming that all students in the school system are the same and have the similar interests (Atkinson, 2012) means rejecting their differentiation according to their characteristics and interests which create the diversity in career choose. The created convergence for the future in STEM fields would result in trouble if we needed more diverse working areas. Therefore, the policy making issue needs to be considered from the perspective of the necessities of a country for the future, and the changes should be made by thinking about the educational, cultural and political bases of the country. When all those considered, integration of STEM education into Turkish educational context seems to have discrepancies. First of all, the needs of two countries are different from each other. While the United States of America works for the raise the number of native employees in the STEM related areas because of the lack of interest towards those disciplines by the United States of America born citizens, there are way more than engineers and natural science programs in Turkey by giving more than 65,000 graduates in those areas in total (YÖK, 2017;2018;2019). Also, in Turkey, the precautions should be taken about the issue of brain drain of citizens after their

undergraduate and graduate degrees in STEM areas. When this is the case, there is a need for the policy which will make use of the graduates and upcoming graduates in STEM areas instead of directing more and more students to those areas. As Mathis (2011) indicated, there is a need of divergence in interests because the aim of the education is to raise good citizens and good human being working for the community's sake. For this purpose, every country needs its own policies to educate individuals by respecting their interest. Also, here are differences among countries making them unique which should direct them to find the right way to form their own policies regarding their strengths, weaknesses, opportunities and threats.

2.6 STEM in relation to equity issues

There are debates and controversies about the definition of the STEM education whether it is an integrated whole or the acronym representing four different disciplines. However, the studies conducted on the equity issues in STEM fields reflect STEM areas as four different disciplines standing for science, technology, engineering and mathematics especially in investigating the gender gap in STEM education (Justman & Mendez, 2018; Bergeron Gordon,2017; Beedee, Julian, Langdon, McKittrck, Khan & Dom, 2011; Yang& Barth,2017; Neigel, Bailey, Szalma& Sims,2017; Xie, et.al.,2015). According to Xie et.al (2015), the reason why there is a disparity between male and female is not the ability lack of female as indicated in a study that there was no significant difference between male and female participants measuring the spatial processing performance (Neigel, et.al, 2017) but is (i) the lack of highly pointed social-psychological notion of females about being in STEM areas and (ii) general misdirected notion about males reflecting them to be naturally talented in math or in quantitative based areas apart from females not being based on any evidence. Langen and Dekkers (2005) state the results of their study which is related to the gender disparities in STEM areas showed that the countries with more "gender consciousness" have higher rate of female participation in STEM fields. Turkey is a special case for the workforce in STEM fields with Bulgaria and Portugal since the participation to those fields in Turkey is higher than the industrialized countries in Europe (Küskü, Özbilgin, & Özkale, 2007).

According to Higher Education Council the cause of this discrepancy between those countries could be because of the centralized placement to the university programs rather than localized selection of the students (as stated in Küskü et.al, 2007). Also, the perception of women in engineering and technology areas shows that there is no discrimination over their gender throughout their educational life or in the working area since there is no visible legitimate discriminant discourse in Turkey (Zengin-Arslan, 2002). However, the masculinity is perceived if we look at the action of males who are in engineering positions. Women stating no discrimination also indicated that the mimes, looks and callings of male participants to women in the field works and in mechanical problems demonstrates males' concerns and question marks about the women in the field who shows higher gender prejudice over women in regard to their abilities and skills in those areas (Kusku, et.al, 2007; Zengin Arslan,2002). According to Honeyspot (2018) which is the leading technology career platform, although the total percentage of women in all workforces is less than the other countries for Turkey with 31.55 % in 2018 data, the one of the highest percentage in the graduates of STEM fields belongs to Turkey among all countries with 37.11% graduates. Despite the fact that the percentage of all women graduates in the United States of America is higher than Turkey, STEM graduates are less in THE United Stets of America when it is compared. However, the participation to the workforce in STEM fields is smaller in Turkey than those countries having less graduates in STEM as a percentage with 9.91% (Honeypot, 2018). There is a dilemma here that is coming from the controversy created by those rates in Turkey. The dilemma in the United States of America is related to something as called unchanged rates of women workforce in STEM fields over time from 2009 through 2015. The comparison of 2009 and 2015 data stating information about STEM workforce in the United States of America shows that there is approximately no change in the percentage of the representation of women in STEM fields with 24% in both reports published by the United States of America Department of Commerce (Beede, Julian, Langdon, McKittrick, Khan & Doms, 2009; Noonan, 2017). That is to say, the initiation of "Educate to Innovate" campaign in 2009 by Obama to gain attention to STEM fields which are thought as the determinant of the place in global economy does not change the participation percentage of women in STEM fields. STEM fields mentioned in those reports are the ones with "hard sciences,

engineering and mathematics" not the ones involving "educators, managers, technicians, health-care professionals, or social scientists" (Noonan, 2017). According to Fayer, Lacey and Watson (2017) in the report of the United States of America Department of Labor, the employment in STEM fields raised by 10.5 % from May 2009 to May 2015. Therefore, it can be said that despite the fact that there is a growth in the number of employment in STEM fields in the United States of America, where STEM education initiatives launched, the women representation in those fields did not changed, it stayed the same. Overall, the research done about the indication of women in STEM fields and gender prejudice about those fields in the world is the representation of equity issues in those fields.

Apart from the gender prejudice, selecting STEM fields as a major to be participated as a workforce for the future is seen by individuals as the job of geeks and nerds. According to the notion about those fields, they can be handled only by the smart ones. This thought also prevents the ones wishing to be in the STEM fields but not seeing themselves as geek or nerd (Langen & Dekkers, 2005) because those words represent the intelligence with antisocial characteristics especially in American version of the words ("nerd",n.d.; "geek", n.d.). The masculine, geeky and nerdy discourse in STEM areas needed to be abandoned to attract the individuals to be a part of scientific and technological developments more. Because of the fact that being geeky or nerdy seems to be an obligatory of those areas, the attraction inevitably decreases towards science, technology, engineering and mathematics not for just women but also for men. According to Berry (2014), having the geeky role for STEM areas is a selling strategy to be used in the field to sell STEM areas to attract labor force in those fields on the contrary of the unreachable crew with non-geeks holding 80% for all non-choosers of STEM. However, reaching all individuals and call them to be part of STEM areas could not be reached by telling STEM area choosers and workers as geek or nerd. Therefore, this notion push people away from working in STEM areas because of the fear being someone known as nerd.

According to all those mentioned, it can be said that the masculine discourse added to nerdy and geeky talks for STEM areas prevents males who do not want to be seen as geek and especially females who are not interested in being in a field seen as the "man

job" because of the technical and operational procedures imputed to males. In order to change this perception some actions are held by states of non-governmental organizations in countries. In Turkey, to encourage secondary school students to be part of STEM areas, especially the ones in fundamental sciences as chemistry, biology, physics, mathematics, technology included departments and also some less preferable engineering departments, The Council of Higher Education announced the scholarship during the first year of their undergraduate education provided to those selecting the mentioned areas as undergraduate study field and taking bachelor degree in the first place beginning with 2016-2017 academic year (The Council of Higher Education, n.d.). Also, the president of The Council of Higher Education states that by the motivation to meet the needs of this country's "qualitative knowledge" production with the raise of "qualitative individual" for the future of Turkey, designating primary areas of study for individuals and directing them to be the part of the growth is what is done with this scholarship act to STEM areas (Sarac, 2018). Apart from the mentioned state act for getting the attention of the young to be part of STEM education, there is a movement started by a foundation for females to add them to STEM areas called as "Türkiye'nin Mühendis Kızları" (Turkey's Engineer Girls). This act is also supported by Ministry of Education and Ministry of Family, Labor and Social Services and international organization "United Nations Development Programme". (Türkiye'nün Mühendis Kızları, n.d). By the help of this act, the aim is to gain more female attraction to engineering field so that the female employment and the female power in the field increase. For this purpose, the collaboration with high schools to encourage female students is done.

Overall, the participation to STEM areas is given importance and movements from both governments and foundations form the edge stone to encourage both males and females with different policies. They need to continue to provide the sustainability and increase in those fields.

2.7 STEM Education and 21st Century Skills

The skills for 21st century are the combination of all skills needed for individuals to survive in all aspects of the life in the age of technology, innovation and information. Apart from the core subjects needed by individuals to survive in social and economic

life as language, reading, mathematics, economics, science, geography, history, arts and government and civics, there are other skills to gain to be a part of labor force in informative way in this age. According to Partnership for 21st Century Learning, the framework for 21st century skills is formed by three main aspects as learning and innovation skills, information, media and technology skills, life and career skills (P21, 2007). For P21 (2007), The learning and innovation skills includes the creativity and innovation, critical thinking and problem solving, communication and collaboration while information media and technology skills are about information literacy, media literacy, and ICT (Information, Communication and Technology) literacy. Life and career skills includes flexibility, adaptability, initiative, self-direction, social and cross-cultural skills, productivity, accountability, leadership and responsibility (P21,2007). Therefore, it can be said that apart from the technical and technological knowledge to be used, individuals need adaptation and self-regulation skills that direct them to be part of solution with their social and cultural skills.

Beginning with the humanity, human-being solve problems of their times all the time. First, it was about eating, harboring, warmup, and basic skills to survive in the environment, then it evolved to understand the world, universe, and try to make the world better to survive. For our age, the survival skills include many things as the time evolved to the one with many technological developments in a limited time. All that time humanity existed, technological developments and understanding the universe were improved with baby steps. At some point, human-being broke the chains and started to develop with huge steps compared to the historical developments. The curiosity existed in the heart of individuals and wish to understand the world in a different manner make them discover again and again. The beginning of this break could be thought to start by the launch of Sputnik to the space and opening to the space that is a new environment for the humanity. This huge step was followed by other steps taking the developments farther than the previous improvements that made the growth exponential rather than linear increase as seen in the Figure 2.1.

Therefore, individuals in the century of technological, communicative and informative developments need different kinds of skills than before apart from the problem solving skills. The return of those rapid ICT developments is the key factor affecting the

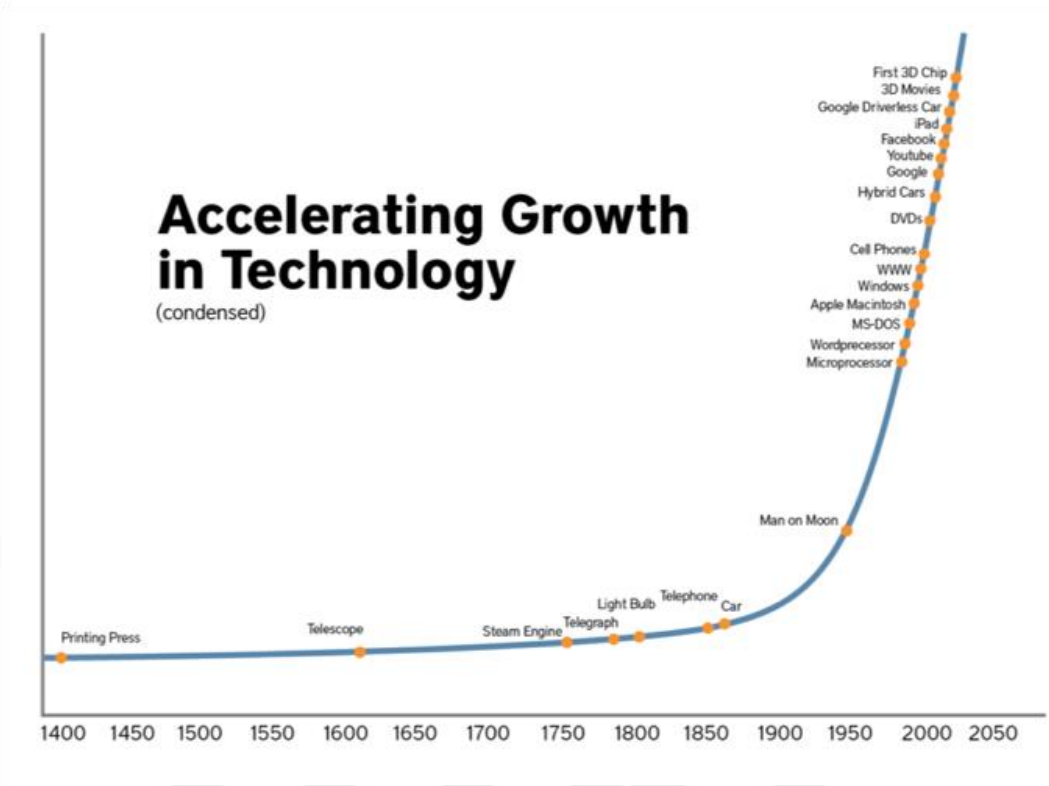

Figure 2.1 Exponential Growth in the Technological Developments Staring from 1400s to the Present (source: Raza, n.d.)

thought about the need for STEM educated individuals in labor force. In contrast to those factors affecting the world in a way to be in the field of science, technology, mathematics and engineering, importance of ethical and responsibility does not take as much attention as STEM because of the lack of the fields covering arts and humanities in STEM processes. Development of ethics and with creative thinking and problem solving skills is the key factor for our generation to work not for the humanity but also for the global world and all creatures in it. Therefore, giving all attention and importance to STEM areas is not the solution for the future of the world but the divergence and integration of different fields enabling people to work for the sake of global world we live is the priority.

2.8 STEAM versus STEM Education

The importance of STEM areas for the development and understanding of the world is inevitable but this is not the solution to the whole problems by itself. The promotion

of STEM areas is done to take attention of more and more people through the way of having STEM careers. The reason behind this purpose is because of the economic concerns of the states. However, states only need is not just economics came by the STEM area developments but the sustainability of the world in a way of leaving this world to next generations in a livable sense. Therefore, the integration of art and humanities is seen necessary to have a creative and sensitive generations. the "A" is the representative of both arts and humanities because the acronym is not for only aesthetical concerns but also the development of human sides in individuals. STEAM is a new concept compared to STEM education raised in 2010 (Herro, Quigley, 2017) but the concept without giving a name to it is used many centuries ago. For example, Leonardo Da Vinci is a scientist using creative thinking and problem based innovations where he also got help from artistic side of the world (Wade-Leeuwen, Vovers & Silk, 2018). That is explained as the necessity of integration to STEM education of art and humanities is not just for "broaden minds" but for the gain of ethical, moral values and responsibility sense to individuals (Lanchman, 2017). In the same article, the importance of doing a job, engineering for this example, not just for writing codes but for the purpose of doing our world more livable for all (Lanchman, 2017). Technological development not for the industrial profits but for the humanity and for the nature is the necessity of our time to give over a livable world and future to our next generations. For the continuity of industry, at some point the duration of the products were decreased that also increase the frequency of changing the owned product with new one and the customers, in this case the consumers, triggered to consume products by replacing it a little newer, a little better, a little sooner (as cited in Lawlor, 2015). The examples for this situation can be arrayed beginning with the Apple and its reduction of CPU (Central Porcessing Unit) performance in the time of releasing new model of IPhone and published an apology letter for the decrease in battery performance after using the phone couple of years (Apple, 2017) While there is a light bulb in a fire station flaming for 119 years now is the proof of this planned obsolescence because of the light bulb producing factory owners made a deal in a cartel they established almost 100 years ago to produce light bulbs which could be used only for 1000 hours but nothing more. This was done to provide the existence of light bulb industry

2.9 School Principals' Roles and STEM Education in Schools

While we are talking about STEM education in school environment, we first need to consider the school environment starting with the head of the school, school principal. School principals are the ones managing school and all the processes in it and for all stakeholders s/he is the one to communicate in the first place. This is how their importance come to the surface with the evidence provided by different studies in the literature (Cranston, 2013). Therefore, school principals need different kind of characteristics which move the school to further. The spirit of every working environment is different and it is also valid for the schools. Every school has its pros and cons which should be identified and the actions taking part in the school should follow those characteristics. The leading person for this adaptation process for every individual in the school is school principal and they need to manage all the processes according to the positive and negative side of the school environment. When the literature is examined for STEM education leadership of school principals, the lack of the studies about this issue reveals. Therefore, their technological leadership roles are searched in the literature since the STEM education requires technological enhancements and technology usage as well as the science, mathematics and engineering. For the school effectiveness which is related with student achievement, school principals could take many roles. Yet, according to Goldring and Pasternack (2006), they provide the most instrumental help by preparing goals and mission for the schools. This is supported by another study stating that school principals are seen as the experts in the integration of technology into classrooms and the technological enhancement in the schools are done with the necessary involvement of school principals into the process of creating a vision about it (Cakir, 2012). Also their perceived roles in technology involvement are facilitation, staff development and communication apart from the other roles needed to have as instructional and technological leadership, coordination, public relation, empowerment, ethics and security (Akbaba-Altun, 2004). As the technological involvement into classroom environment requires vision, STEM education needs the formation of vision statement, too. Brown, et.al. (2011) indicated that although this educational approach seems important, there is no clear vision about STEM and how it could be implemented. In order to do this, there is a need for leadership of school principals who should have the

knowledge about STEM education. Yet, Cevik and Ozgunay (2018) stated that school principals' in Turkey heard the term STEM education from TV, internet, conference or social environment, and their awareness about the concept is insufficient.

Apart from this study, the investigation of the knowledge of school principals has not been investigated. Yet there are many studies related with the technology leadership of school principals. the importance of technology leadership for bringing the technological usage into classroom environment has started to be investigated mostly in 2000s. For example, the key role of school principals for technology integration to the curriculum and being the inspiration of the teachers for the implementation is indicated by Flanagan and Jacobsen (2003) which is also important for the school reform movements. In addition to this study, another study indicated that although the infrastructure is important for the integration of the technology to the classrooms, school principals' role of technological leadership is more important for the technology related outcomes (Anderson & Dexter, 2005). In addition to the technology leadership and its contribution to the technology usage in the schools, one of the study suggested that there is a need for professional development of future administrators about components of transformational leadership because the transformational leadership could enhance the usage of computer in the classroom environment according to the results of their study (Afshari, Bakar, Luan, Samah & Fooi, 2008). In the light of those studies, it can be said that for the integration of STEM education to the schools, there is a key role that school principals should take on as in the case of technology integration. For that reason, school principals should harmonized the expert power required to direct the teachers and students with the knowledge necessary to implement those practices with the leadership roles they need to have for the integration of STEM education (Hoy and Miskel, 1987).

Overall, creating an environment for STEM education requires forming vision, mission and goals after gaining the proper knowledge about the concept STEM education and its implementation processes. In addition to those, school principals need to provide sufficient environment for communication, facilitation and leadership by using their expert power as a source of direction. Even though there is a lack of studies approaching STEM education from the perspective of educational

administration, the educational change and reform is not a new area discovered. Therefore, policy development and policy borrowing issue is the key factor of STEM education that should be discussed for the future of the concept as mentioned earlier in this chapter. In addition to this, the role of school administrators in the implementation of new concepts is to work for the inspirational and leadership purposes that could lead the way of teachers for those implementations through the direction of expert power they need to have.

2.10 Summary of Literature

In addition to the adventure of STEM education and its reflections in the countries, the review of the literature showed the contradictions, gaps and policy issues regarding the STEM education as well as epistemological lack and the need of the consideration of human side of the individuals by integrating arts and humanities into the STEM concept. Overall, after the literature review, it can be said that there is a need for more consideration on STEM education as a policy and educational administration issue. There are lacks in expertise, curriculum, definition, policy borrowing, social justice issues. The published report by MoNE (2016) also showed the lacks as an obstacle against the implementation of the STEM education as teacher preparation needs, curriculum change needs, rearrangement of school facilities for SETM implementations, the need for research about STEM education. therefore, this current study aims to close the gap in the literature by approaching the STEM education issue from the perspective of the educational administration and the perception of school administrators as the leaders and the ones need to have the expert power.

CHAPTER 3

METHOD

3.1 Design of the Study

In general form, the difference between quantitative and qualitative research can be expressed as the difference between the "hard" sciences such as mathematics, physics based on formulas and hypothesis and "soft" sciences like biology (although this thought is changing in recent years) and social sciences not depending on those (Guba & Lincoln, 1994). After the ruling term of positivist approach in science beginning with the Renaissance, the world evolved to the acceptance of other paradigms such as post-positivism in a sense that the world is not formed only by black and whites but there are greys. Unlike the positivist approach, post positivism does not support the objectivity and seeking "the truth" but promote the point of view and the observation of natural settings to get the meaning formed by existence of multiple truths and perceptions (Yildirim & Simsek, 2005, p. 25-27).

As mentioned by Bogdan and Biklen (1998, p. 4-7) qualitative research have five features as trying to understand the natural setting, describing the environment through the explanation of what is seen, focusing on the process rather than product, collecting every valuable piece of data to reshape the picture again and again until it gets the latest form and lastly seeking the "meaning" created by the thoughts of the participants, observation of the environment and the document analysis done. Therefore, the focus of the qualitative research is different than quantitative one with respect to their "truth" and "meaning" understanding and choice of "process" or "product". Focusing on the process, which produces a product at the end, provides in–depth understanding of the environment because of the fact that it reflects the natural setting by interviews,

document analysis and observation (Denzin and Lincoln, 1998, p.2; Patton 1987, p.7). The common ground formed for qualitative inquiry brings the focus of "experience", "understanding" and "meaning" (Bogdan & Biklen, 1998; Patton, 2002). Individuals' perceptions formed by their prior experience give them a way to understand the environment and describe it in their own terms (Patton, 2002). That is why the qualitative inquiry is more interested in the process not the product.

In the light of those describing qualitative inquiry method, the purpose of the study is to investigate the understanding of school principals about STEM education, and find out the STEM practices in their schools and their role in development and implementation of these practices. Therefore, qualitative research method is chosen to be the one to carry out this study specifically.

3.1.1. Phenomenology as a Qualitative Inquiry Method

To prevent carrying out unorganized research that has uncertainty, a study needs a theoretical framework enabling the researcher to stay in the path without any loss in the way (Bogdan & Biklen, 1998). According to Bogdan and Biklen (1998), one of the theoretical perspectives for qualitative research is phenomenological approach which can be described as one of the main points in qualitative research. The focus in phenomenology is the "lived experience" of individuals and the reflection of those experiences in thoughts, actions and assumptions for a phenomenon (Creswell, 2007, p. 57; Patton, 2002, p.104) which is neither too similar nor too far away from the experiencing individuals (Yildirim & Simsek, 2005, p.72). In other words, the phenomenon investigated is not fully understandable for participants but it is the part of the experience they are going through and have ideas and thoughts about the phenomenon (Yildirim & Simsek, 2005, p.72).

In this study, phenomenon is STEM education since it is the current subject that all the world being interested in educational practices. Therefore, the perceptions and opinions of school principals in secondary education level was investigated. Fraenkel, Wallen & Hyun (2015, p.430) asserts that phenomenological research is mostly based on the in-depth interviewing aiming to attain comprehensive understanding of the world of individuals and to get their perceptions and reactions about the phenomenon.

Because of the fact that the opinions and perceptions of school principals is the one wished to deeply understand, semi-structured interview is used to collect the data. Also some documents such as the journals, web sites were searched.

3.2. Research Question

The aim of this study is to find out the "meaning" of STEM education for the school principals reflecting their "lived experience" and perceptions about the concept. This perception could be based on their opinions, assumptions or their actions in schools regarding to applications done. Not just their perception about STEM education but their perception for their role in the teaching and learning process is asked in interviews. Therefore, the research question(s) of this study is/are:

1. How do the school administrators in high schools perceive the educational trend of 2010s "STEM education"?
2. What are the experiences of school administrators in STEM practices?
3. How do school administrators define their roles in STEM practices at their schools?

3.3. Participants of the Study/ Population and Sample

STEM education has been investigated with different stakeholders of schools as well as the universities, mostly with students, teachers and pre-service teachers. On the contrary of variety of studies for STEM education, there seldom investigations on schools' principals. However, school principals are the leaders of teaching and learning environment and their openness to change, leadership skills and support of innovative applications constitutes importance. Thus, the group of participants are the school leaders for this study to understand their perception regrading to the STEM education.

The participants were chosen from the secondary school level since this level constitutes a critical period in the lives of the students as they make the critical decisions regarding their university study program and professional life. In Turkey, there are six basic secondary school type as Anatolian High Schools, Science High

School, Social Sciences High School, Vocational and Technical High School, Arts High School and Sports High School, Anatolian Imam and Preacher High School (Ministry of National Education, 2018a). From those, Anatolian High Schools, Science High School and Anatolian Imam and Preacher High School and Vocational and Technical High School are selected. The selection was based on the criteria of taking students based on the Secondary School Entrance Exam (Lise Giriş Sınavı-LGS) done by Ministry of Education. The importance of this exam for our selected schools is because of the entrance exam does not include every high school but the "Science High School, Social Science High School, Secondary Education Instıtutions Implementing Special Programs and Projects (Özel Program ve Proje Uygulayan Ortaöğretim Kurumları)" (Ministry of National Education, 2018b).

The study was conducted in Ankara province, the capital of the country. In Ankara there are 82 high schools matching with the criteria out of total 795 secondary schools including 464 general secondary schools and 331 vocational and technical secondary schools (Ministry of National Education, 2018a) in total. Therefore, it can be said that 10.31% of the secondary schools in the province accepting students with Secondary School Entrance Exam. The schools of the population which the sample chosen is represented in below in Table 3.1.

Table 3.1

The spread of the school types taking students with entrance exam in Ankara Province

Secondary School Type	Number of School
Anatolian Imam and Preacher High School (AIPHS)	14
Anatolian High Schools (AHS)	16
Science High School (SHS)	12
Social Sciences High School (SSHS)	4
Vocational and Technical High School (VTHS)	36
Total	82

*Those numbers are from the guideline announced by Ministry of National Education (2018) for the centralized exam for the secondary school entrance.

In addition to criterion sampling (Patton, 2002) for the study, the schools are decided regarding their possible tendency towards STEM education. Sampling is done by choosing the participants from three different secondary school type with different practices and curricular activities as Anatolian Imam and Preacher High School, Anatolian High Schools and Science High School. Moreover, criterion sampling is chosen because there is a predetermined criterion which is taking students with entrance exam covering only 10.31% of the total secondary schools in Ankara province.

Table 3.2

Descriptive about school principals

	School type	Gender	Discipline
1	Anatolian High School	Male	Turkish Literature
2	Anatolian Imam and Preacher High School	Male	Turkish Literature
3	Anatolian High School	Male	
4	Anatolian High School	Male	Culture Of Religion and Ethics
5	Anatolian Imam and Preacher High School	Male	History
6	Anatolian High School	Male	Turkish Literature
7	Anatolian High School	Male	Culture Of Religion and Ethics
8	Science High School	Male	
9	Anatolian High School	Male	French
10	Anatolian High School	Male	Mathematics
11	Science High School	Male	

The interviews were done with eleven secondary school principals in total. While two of the school principals were working in Anatolian Imam and Preacher High School, seven of the school principals were from Anatolian High School. The rest two school

principals were working in Science High School. The descriptive about school principals are presented in the Table 3.2 above. In addition to those information, it can be said that while one of those interviewed school principals have Master's Degree, another school principal was doing his PhD at the time the interview has been conducted. Also, the school principals are experienced about school administration as they indicated. According to Lincoln and Guba (1985), the purposeful sampling size is determined by the information taken from the participants. When the information is reached to the maximum point, gathering data is ended because the point of redundancy is reached (as cited in Patton, 2002). Therefore, the point that data collection is stopped when the information taken from secondary school principals give no further data added to the heard ones.

3.4 Data Collection Instruments

In this study, two qualitative inquiry method instruments were used. First, is the semi-structured interviews done with the school principals. Second method used was the document analysis done by the investigation of the web sites of the schools where the school principals interviewed work. According to Yildirim and Simsek (2005), interviewing is the most commonly used tool in qualitative inquiry. Interview is a way to understand the perspectives of the participants since intentions, thoughts, the reasons of acts could not be observed but it is meaningful when it is taken by self-reports (Patton, 2002). For this purpose, interviewing technique is used in this study to deeply understand the perception of school principals and semi-structured interview was constituted.

Because of the lack of information about STEM education in the world, there are a few frameworks that can be considered while forming interview questions. The detailed framework formed by NYC Department of Education with the name of NYC STEM framework. This framework has four main domains with including subdomains in each. Mainly domains include (i) school vision and structure for success, (ii) STEM curriculum instruction and assessment, (iii) strategic partnership and (iv) STEM college and career readiness which includes planning and preparations for K-12 level. While forming the interview questions, those domains and the expert opinion was taken into consideration. Instrument include interview questions related to educational

practices and curriculum applications in the school differentiating the school from others, the harmony of mission, vision and goals of school with STEM education and the resources needed for those to make real, the perception of school principals about STEM and STEAM education, their sense of their role for STEM educational practices and the understanding of the reactions coming from teachers and students.

In the process of forming interview questions, two expert opinion is taken who have extensive expertise in educational research, qualitative research methods and STEM education. The questions are revised several times before finalizing the interview guide, on the basis of the opinions and recommendations of the experts. The final version of the semi-structured interview guide had fourteen main questions with seven sub-question in total used to deepen some questions (See Appendix A).

In addition to the interviews, document analysis has been done for the schools that the interviewees work. The document analysis process includes the investigation of the web sites of the schools as well as the strategic plans and mission, vision statements of the schools. The investigation of the web sites is done to understand what STEM education experiences are seen in the schools. During the document analysis, as Miles and Huberman (1994) suggested, data reduction procedure have been used to discard irrelevant data. The irrelevant data was determined by whether the strategic plan documents, announcements, news and the school practices announced in the web site include STEM related implementations or not. In addition to this, the news and announcements were investigated in relation to arts and humanities because of the possible STEAM education implication. After all data are collected through the analysis of web sites, those documents related with the current study were used.

3.5 Data Collection Procedure

After finalizing the interview guide, an application for the approval of the Human Subjects Ethics Committee (HSEC) at METU is done in May 2018 (see Appendix B) and the permission is taken in June 2018. After granting the approval of the HSEC, the legal permission of Provincial Directorate of National Education in July 2018 (see Appendix C) and subsequently, the data was collected between August 2018 and February 1, 2019.

After getting all the permission, the schools notified to HSEC and Ministry of National Education are again listed. Then in August 2018, it was started to conduct interviews with school principals. The ones who volunteered to participate to the study and the ones who have experience in the same school more than 4 months are selected which is because of the questions in the instrument could not be answered without knowing, experiencing and observing the school setting, teachers and students for a period of time. Also, in two schools, the interview was conducted with the vice principals rather than school principals. The reason why it is interviewed with the vice principals is because for the first school the principal directed the STEM education practices in school to the vice principal interviewed and for the second school it is because of the lack of school principal because of the appointment procedure and the vice principal was the school principal by proxy. For the remaining nine schools, the interviews were conducted with the school principals. All of those eleven school principals volunteered to participate in the study and signed the informed consent form (Appendix D).

The interviews took at least 17 minutes and at most one hour and 24 minutes. Taking into account all interviews, the average time is approximately 43 minutes.

In addition to the interview, document analyses were also done to enrich the data about the STEM practices, perspectives and approaches towards STEM after the interviews were done. Analyzing materials posted on websites of the schools and searching the strategic plans of the schools were the used strategies for the document analysis. Document analysis can be used as an additional tool to interviews or observation or both providing the raise of the validity by confirming the data triangulation of the study with another data collection tool (Yildirim & Simsek, 2005). In this study, document analyses provide evidence for developing a holistic perspective on the phenomenon, that is STEM education from the perspectives of the schools and principals.

As indicated by Patton (2002) documents provide information that cannot be observed directly with a wide timeline starting before the evaluation of the phenomenon began and ending long after the interviews are done. In this study used documents consists of the web site materials of high schools that includes news and announcements showing their activity based collection of information. Those documents published in the web sites are the ones the school thinks it as important, proud to be or different

applications they are implementing. Also the strategic plans of those schools also investigated to see whether STEM related aims, goals of strategies are appropriate. For some schools there were not any available strategic plans so their mission and vision statements were analyzed. The enrichment of the current data with documents available is important for the understanding of the nature of schools in addition to the thoughts given by principals about their schools.

3.6 Trustworthiness

Although the nature of qualitative and quantitative studies is different from each other, the validity and reliability issues need to be satisfied for both research methods. However, their way of validity and reliability validation differs as well as their nature of inquiry. The nature of qualitative research requires to "be in the field" which could also cause misleading of researcher while trying to understand a phenomenon (Fraenkel & Wallen, 2015). Since the instruments of validity and reliability fitting into the quantitative research do not fit into the nature of qualitative research, the trustworthiness of the findings in the qualitative study is done through the test fitting into the nature of qualitative research for validity and reliability. The terms of credibility, transferability, confirmability and dependability presented by Lincoln and Guba (1985) for trustworthiness of qualitative research. In order to satisfy the terms of trustworthiness there are eight different validity and reliability verification procedures as Creswell (1997) explained as prolonged engagement and persistent observation, triangulation by using multiple sources, methods, investigators or/and theories, peer review or debriefing, negative case analysis, clarifying researcher bias, member checks, rich, thick description and external audits.

In this study the triangulation and peer debriefing are applied. According to Patton (1987), the triangulation of the data could be done through using different kinds of data collection tools, using different interviewers, using more than one method to study, or using different theories. Generally, the most preferable triangulation method is using more than one data collection tool or data sources (Creswell, 1997). In this research, that was chosen as the triangulation method by investigating the research questions by interviews and document analysis as approaching the issue with different

data collection tools provides in depth understanding of the school principals' perception, experiences and role about STEM education practices.

Apart from triangulation, peer debriefing method was used. After the transcription of the data gathered are done, the three different data were analyzed by four research assistants according to the research questions of the study as well as codes and themes revealed. Those four research assistants have experience in qualitative research method and they are from educational sciences department and they were all familiar with the present research. The necessary editing on the data was done based on their suggestions.

Moreover, the clarification of the researcher bias is important since those could have effect on the results of the study. therefore, those are explained in the limitation section of the study in Chapter 5. (Section 5.3)

In addition, those verification processes explained by Creswell (1997), the procedure of recording the interviews was done when it is permitted by the school principals. Since the recording helps to catch every expression made by the participants, it made the data analysis procedure easier (Kondakci, 2005).

To sum up, the trustworthiness of this qualitative research is ensured through triangulation, peer debriefing, clarifying researcher's bias and recording of the interviews in order to provide validity and reliability fitting the nature of qualitative research.

3.7. Data Analysis

In this study, the data collected through interviews are transcribed verbatim and the document analysis is done by the investigation and transcribing of the web site documents as news, announcements, strategic plans and school properties. After the data collected is organized and transcribed, they were analyzed through the MAXQDA 2018.2 in order to benefit from the program for the qualitative data analysis as reaching the codes labeled in all documents, reorganizing the themes and codes when it is necessary, reaching the files easily and having organized codes and themes. After that, the analysis of the data was done by two analysis type of qualitative inquiry as

qualitative description and content analysis. In the qualitative description section, the school environment and the school principals' characteristics and overall perception about STEM education are described to provide general description. After those descriptions are presented, the content analysis which is the in-depth investigation of the data is done by providing quotations about the themes revealed. Nine themes were revealed from the data about the school principals' perception, experience and role in STEM education which are the research questions of the study. those will be discussed in the next chapter profoundly.

CHAPTER 4

RESULTS

This chapter presents the results of the study under qualitative description of research context: the schools and content analysis categories. Patton (1987) emphasized that in qualitative analysis there is no right way to present the results of the study. From the suggestions for reporting the results, the researcher could pick the ones fitting to the study. Therefore, in this section both qualitative description and the content analysis of the data gathered by interviews and document analysis are presented. The qualitative description provides superficial representation (Yıldırım & Şimşek, 2005) of the data gathered but it is useful to execute a holistic perspective of all data (Patton, 1987). Patton (1987) describes content analysis as basically labelling the data by separating them into smaller, meaningful pieces called as themes or categories and reporting on those by giving quotations and example from the original data sets. The understanding of reporting qualitative research is followed in this study as well. The purpose of this study is to understand deeply the perception of school principals about STEM education and their experiences regarding STEM practices at their schools as well as how they define their roles in STEM practices. This study was conducted in Ankara province with the school principals working in prominent schools of the country according to the standards.

4.1 Qualitative Description of Research Context: The Schools

In this section the schools and the interviewees are described by explaining the environment in which the interviews were done and the impressions throughout the interview procedure to form a holistic perspective about both schools and the

interviewees. The participants are coded as P1…Pn in order to ensure anonymity and also track the source of data.

School 1 - Anatolian High School (P1)

While talking about STEM applications, before going any further the indication of the schools' physical facilities is necessary since this could make space for STEM implementation. The school has infrastructure of FATİH project as it is indicated in the website of the school. Also there is a computer technologies class in addition to three science labs. Apart from those there is a library available. The vision statement of the school emphasizes raising the individuals who can lead the way of the enlightenment and have both awareness, ethics, moral values and the knowledge to share and spread the wisdom. The mission is the embodiment of vision statement stating that they are already raising the generations with the knowledge necessary. In those statements there was indication of raising scientists, engineers, doctors as well as the having physical facilities required for modern technologies but no indication of STEM applications or any interdisciplinary applications.

When the principal is asked to describe the environment of the school, the principal emphasized the regular/ordinary public school nature of the context. The only difference from other schools is its preparation school for foreign language learning given before starting to ninth grade. Besides, the principal emphasized a lot about the studies for the personality growth of students with variety of social activities. In addition to the teaching learning environment, he also stated the quality of students and highlighted the highly motivated state of the students. The students are open to learn and they are eager to try new things. Although there is no application regarding to STEM education, his opinion about STEM is that this is not so much understood in Turkey and it is restricted to the applications in robotics. Apart from this, during the interview he shared his knowledge about STEM education and their application fields.

School 2 - Anatolian Imam and Preacher High School (P2)

In the mission statement of the second school, there are ambitious statements indicating the motivation to raise the individuals as leading, respectful and responsible

by leading the way among Science and Humanities Project schools and in foreign language studies. The vision statement includes the aim of trying to spread religious teaching based on respect to ethical and cultural heritage. As it can be inferred from those statements, there is no indication of STEM applications but being a leader school in Scientific projects is involved to the mission statement. Apart from this there are three laboratories besides computer and technology classes. Also there is a library available.

In this school, the interview was conducted with the vice principal since school principal assigned him the practices about STEM. Vice principal's field of teaching is Turkish literature and he has been the vice principal of the school for two years, since the school opened. He indicated that the school has wide range of physical and technological opportunities compared to other public schools. In this school, they are able to select their students with an examination from the middle school level that seems as an advantage according to the vice principal. His notion about STEM points out both sides of this educational trend. First, it can be useful and could give advantage to create more meaningful learning environment. On the other side, being enthusiastic for a flash in the pan –STEM education- is an area requiring to be careful. The analogy with FATİH project with STEM was done to say that sometimes the physical facilities could not be enough to actualize the preferred results. Apart from this his notion about STEM education is based on robotics, applications converting theory into practice. Moreover, some club activities are available that he sees as close to STEM education.

School 3 - Anatolian High School (P3)

This school has the vision of being the school every student wishes to be in while the mission states that creating quality school environment where it is important to raise individuals who are both aware of their responsibilities and abilities and creative in problem solving with the acceptance of learning as a prior need. Therefore, it can be said that in mission and vision, there is no sign of STEM education but the academic growth is the priority for the school as well as the development of human side. As in the first two schools, in this school there are three laboratories, one library and one computer and technology class.

The interview was carried out with the principal of the school. He has been serving the principalship position for more than four years. He indicated that they utilized some components of FATİH project in the school for a long time. The principals exhibited a critical approach to STEM movement in Turkish Education System. He shared this notion about the borrowed policies by giving the example of TQM (Total Quality Management) and its failure in Turkey because of not fitting the structure. He has some thoughts about STEM as well and states the capture of university entrance examination on students bringing about the negligence school practices. Furthermore, there is no application of STEM or any related (from the STEM perspective of the principal) activities in this school.

School 4 - Anatolian High School (P4)

This school holds an ambitious vision, indicating the motivation of "being the brand school" while the raise of individuals connected to each other with love, respect and trust who have also the knowledge needed in this age, and keeping the job satisfaction of the employees high, and lastly pleasing the parents is the mission statement. Therefore, it can be said that the school's mission and vision statements do not have direct relevance to STEM education. The school has one science laboratory, one computer and technology class and one library but there is no indication of FATİH project infrastructure in the school.

The principal was the interviewee in that school whose field of religious studies (culture of religion and ethics) and he has been the principal for more than four years. Apart from the indication of the quality of teachers, the emphasis on TÜBİTAK science awards of some students was also done. However, about STEM education, there was no indication from principal about it as both implementation and knowledge.

School 5 - Anatolian Imam and Preacher High School (P5)

Being leader and a model school constructing the future of the country is the vision statement of the school. The mission of the school emphasizes growth of students' religious learning and actualizing in the light of national culture and global values and their rational and scientific thinking skills. As it is seen from those statements, STEM

related expressions were not placed into the mission and vision. But they stated the importance of scientific thinking. In relation to physical infrastructure for STEM, there are two computer and technology classes, six scientific labs and two libraries. The rich library sources were also specified by the interviewee with more than 26,000 books and access to the library in week days and weekends. As a different application from other public high schools, in this school there are rooms reserved regarding to field of teaching to support the collaboration of learning community. Also, there is FATİH project infrastructure.

The interview was conducted with the school principal whose field was history. He has been in this position for more than 4 years. He stated that he is not familiar with the term of STEM education and its meaning. He indicated that TÜBİTAK projects in mathematics, physics, chemistry and biology fields as well as the trips and collaborations with ASELSAN, TÜRKSAT, CERN make STEM education attractive. Finally, the wide physical opportunities for the students, the quality of students and teachers were indicated strengths of the schools.

School 6- Anatolian High School (P6)

Being an outstanding and a model school by responding to the expectations of all the stakeholders to reach the perfection in education is the vision of the school. The slogan of the school is being an exclusive public school. The emphasize of all stakeholders' mission in the school is to raise generations connected to the Atatürk's principals and reforms, combining national values with the global ones, having peace with the environment and the oneself, having clarified goals and awareness to reach them, owning the problem-solving skills, taking advantage of knowledge and technology in behalf of creating our future in safe hands. On the contrary of the indication of taking advantage of technology, there is no computer and technology class in the school. Three science labs and a library are available in the school. The principal or related documents did not mention FATİH project infrastructure.

The interviewee was the principal and he has been the principal of the school since for four years. He has a general notion about STEM education and STEM practices exist in the school and curricular practices. The principal tends to perceive STEM as four

different disciplines and he gives credit to teachers in science and mathematics fields for implementation. The interviewee was the only principal who indicated YEGİTEK in-service training about STEM education for teachers. For him being in the engineering fields and especially encouraging girls to be part of those areas is important. Finally, he attributes value to his role in STEM practices as a principal and a leader.

School 7 - Anatolian High School (P7)

The school identifies the mission of raising good citizens and the vision of being in top ten schools nationwide in the placement of students in prestigious higher education programs. Hence, academic achievement and contributing to the development of the labor force and good citizens of country have been identified as key goals of the school. However, there is no evidence for STEM education in its vision and mission statement. In terms of STEM-relevant physical infrastructure, there are one science laboratory and a library but no computer and technology laboratories.

The interviewee was the school principal whose field of teaching was religious studies and ethics. He has been serving the principalships in the school for more than four years. His ideas about STEM education is based on the experience of his engineer son who combines all STEM areas while working. Therefore, he thinks that STEM education can contribute to high schools in a positive way as there are studies and preparations of MoNE about STEM education. Apart from those he thinks every school have its own spirit where the new comer, even if he is the principal, needs to fit by learning from the experienced ones. Therefore, it can be said that he is willing to sustain the school culture ongoing in the communication and teaching and learning environments.

School 8 - Science High School (P8)

The vision of the school is to be model and leader. The mission of the school is raising individuals for scientific studies by combining owned abilities and knowledge. Producing projects, entrepreneurship, volunteer to team work, creative, thinker in multiple ways, giving importance to process not the result, self-confidence, being

aware of one's abilities, and humanism are the key values of the school, which are believed to serve the whole country as well. That shows the goal of the school as giving importance to the individual growth of students with 21st century skills. In the school there are three science labs, one computer and technology class and a library with wide range of sources in different languages for scientific research and literature. In addition, there is FATİH project infrastructure.

The vice principal of the school has been in this position for more than two years. According to interviewee, STEM is for actualizing the complete learning and this trendy educational practices are implemented in the school. This school has many collaborations with institutions as ASELSAN, HAVELSAN, TÜRKSAT and universities. Projects prepared for TÜBİTAK, replication of some experiments in universities, meetings with engineering and science based institutions' managers are some activities aligned with STEM education at this school.

School 9- Anatolian High School Principal(P9)

This school has the vision of raising the leaders of the future and the mission of raising individuals who undertake national values and responsibilities. Developing independent, productive individual and with scientific orientation who can serve the country to and follow Atatürk's principles is the key concern in the mission of the school. The statements do not include any kind of sign about implementation of STEM in the school. In the school in addition to two computer and technology classes and three science labs, there is a library available. In addition to those there is FATİH project infrastructure. Apart from those as observed when gone to school there was a class saying "house of inventors" (Mucithane) prepared with the lead of principal but because of the lack of infrastructure it could not make any progress and is not open for the usage.

The principal, who was the interviewee, has a long experience of principalship but he has been serving the principalship position for two years in the current school. His field is French language teaching. As indicated by the principal, there is no implementation of STEM in the school. The principal mentions TÜBİTAK projects in scientific areas as the only involvement of the school in STEM education. The concern

of principal about STEM is that it requires interdisciplinary approach, necessitating the collaboration of different fields of teaching. To implement STEM education in schools, he thinks that the works of school on its own are not enough for the application but the support and direction of MoNE is necessary. He believes the importance of interdisciplinary works.

School 10 - Anatolian High School Deputy Principal (P10)

The vision of the school indicates the target of accomplishing 100% success in higher education entrance, actualizing learning with full of technology and creating a nurturing environment for self-development of all internal stakeholders. The mission statement emphasizes that this school is for students to catch the opportunities of today and the future and to be individuals using their abilities and knowledge at maximum level. As in some other sample schools, there is an indication of the usage of technology for the individual development of students in vision statement. Apart from this, there are a computer and technology laboratory, a library and two science laboratories. FATİH project's infrastructure was not mentioned for this school. In addition to those, there is a "garage" opened at the beginning of the 2018-2019 academic year where technological and scientific studies will be done by students with the support of teachers. There is also a 3D printer for those studies. The reason why they called it a "garage" is about the concept that is spread from United States of America expressing the idea of working even in a garage to start production as Steve Jobs and Steve Wozniack did in the time of Apple establishment. There is a room saved for biology practices where students and biology teacher grow fungi by setting all needed environmental arrangements.

The interviewee was the deputy principal who actually works as vice principal at this school for five months. Although his time could be seen as limited, he is in the team who opened that garage in the school. He admits that even if there are physical opportunities and supplies, there is no usage of those in the practice. The implementation of the courses is as ordinary classic approach to the learning. He believes that to form a teaching and learning environment full of practice and theory going hand in hand, there is need for education campuses where students will have full access to all facilities as computer classes, laboratories 7/24 for high schools. He thinks

that STEM education could provide a holistic learning. However, for STEM integration to our schools, there is a need for entrepreneurship of students as well because without this ability, this economic goal of STEM education could not be realized.

School 11 - Science High School Principal (P11)

In this school raising healthy, happy and ready individuals to move on to the next level of education and life was the main focus of the mission statement. The mission statement is to create an environment where individuals are raised as having competence of thinking, understanding, research and problem solving, equipped with the ability and knowledge required in information society, having interiorized national culture, humanity and the global values of democracy, open to communication, having artistic view, self-confidence, self-respect, justice and responsibility, entrepreneur, diligent, creative, innovative peaceful, healthy and happy. In this statement there is a given importance to information society but not about STEM education. There is no computer and technology class in the school but there are two science labs and a library. The FATİH project infrastructure is not available in this school.

The principal of the school was the interviewee and he was working in that school for five months as the principal. He has not much information about STEM education as he was indicated but his notion about this holistic approach to teaching is not applicable and could not be successful. His given importance to the social abilities and entrepreneurship for those academically successful students is main subject for him, not STEM.

Conclusion on Qualitative Descriptives

In this study, even though the school principals interviewed are working in the high schools considered as the best in Ankara province and even in Turkey, they lack knowledge for this emerging, current educational trend "STEM education" which created a stir globally and locally. The descriptive results on the schools' vision, mission statements, key goals; the physical infrastructure; and leadership perception of STEM clearly indicate the lack of readiness of these prominent schools for what is

labelled as STEM education. The only exception to this conclusion is one of the science high schools. In that sense, STEM movement does not have a promising future in the schools where the study was conducted.

First of all, the vision and mission statements of the schools are important because those statements lead the actions in the school to reach the vision and provide the existence of the mission statement. One of the school principals stated that those statements are formed around the pattern specified by MoNE; therefore, they could not change the direction of the statements. The role of the school principal is to take lead to realize those statements. When the compatibility of their mission and vision statements with STEM education was asked, different answers were received. For example, one of the school principals said that "I do not have knowledge about STEM education but if we imply science, mathematics and engineering fields to support each other and help students to shape the knowledge in that sense, then it is in our mission statement." (P5). Another school principal talked about their goals and said that "We open Garage at the end of a year. We need to increase the number of the students using the garage in the second year." (P10). That is how he connects his role in STEM education with the goal of the school. Another school principal having STEM applications in the school stated that

> We have a goal to contribute to the development of Turkey. We raise individuals who have goals, are good person, and helpful to the society. They could get in to METU Mechanical Engineering and do some good work. But the important thing is to be helpful and contributor in the other places. (…) In order to make the student projects happen, we need STEM education and we contribute to that in the direction of our vision and mission statements. (P8)

One of the school principals stated that there is a need for time and improvement to integrate STEM education into the schools' mission and vision statements by saying "In my opinion, there is no knowledge and equipment to integrate STEM into our mission and vision statements." (P1)

Therefore, as it is described in the qualitative description section, there is no match of the vision and mission statements with the STEM education for the schools which is also supported by the many school principals. Some school principals still think that

they have goals and statements that support the STEM educational practices and they try to realize those with their applications. The reason why vision and mission statement were related to the school principal role in STEM education is that they are the ones who have a role to make those statements realized or provide the environment to realize as the head of the schools. However, as it can be seen from both the statements and document analysis, there is no indication of STEM movement or STEM education reflecting no promising future for STEM education in those featured schools.

Secondly, the infrastructure of the schools is not compatible with the STEM education as indicated by school principals and from the document analysis. Some of the schools do not even have FATİH infrastructure which provides schools tablets, computers, internet and smart boards to use in teaching and learning environment. Additionally, one of the school principals emphasized that when it comes to the STEM applications in the school "The best example I could give about this (STEM application) is the biology and chemistry lab. The lab of these two fields is joint. Maybe, there could be study fitting into STEM education." (P9). This statement is the reflection of both lack of readiness as the knowledge of STEM education d not match with the literature and the infrastructure since there is only one lab located in the school open for the usage of biology and chemistry. Another school principal stated that "I speak openly that I have no place in the school that could be accepted as STEM room or anything close to it."(P5) that also indicates the lack of infrastructure.

The school which attempted to have a STEM place is the one opening "garage" according to the information school principal gave. There are a 3D printer in that garage and some other materials that could be used for STEM applications. Yet, he specified that

> We open the STEM garage; we need to raise the number of students reaching this facility in the second year. (…). STEM education is not in the classes. You could teach the theory and logic in the class, but there is application phase too. For that reason, you need to study all night long if required. You can find three or four teachers among the 1000 teachers. (P10)

When the analysis of the documents is done, it is seen that there is just one indication of STEM in the educational environments which is already told by the principal (P10) as STEM garage. Apart from this, there is a trip done to STEM Makers activity but it is not the integration of STEM to the educational context. However, when the school principals heard about "STEM as interdisciplinary approach", they come up with the idea of the science labs where there could be STEM applications. For most of them, STEM means the practice and implementation but not the theory. Besides, they admit that the educational practices in the school are generally working with the traditional classroom environment which is mostly lecturing.

Lastly, school principals need to have readiness and awareness for new implementations to take a lead in the school. However, this is not the case for STEM education. Although those are the schools seen as the best among high schools claiming to raise the qualified individuals for the future, there is lack of readiness and awareness about STEM education even in these schools and school principals. Therefore, they could not take the leadership role for the STEM implementations as they have the instructional leadership role leading teachers and students for the implementation of curriculum and raising the awareness and readiness about the implementations which differentiate schools from others. While there is lack of knowledge in the head of the school, how an idea or educational practice could be implemented requiring teachers from different teaching areas to work together to realize interdisciplinary approach to learning. For those claiming to implement STEM education, they have a notion that there is a need for altruistic teachers supporting students for STEM education and they emphasize that the importance of the participation of teachers voluntarily to this application process to make a difference is inevitable. Therefore, it is valid for STEM education as well since it requires to learn a new concept and try to implement in the school together with the other teachers, students and school principals. The principal from one of the science high school stated the situation as

> We could not make it happen all the time. In the project terms, our teachers and we make sacrifices to help students after 5.00 p.m. until the midnight 2.00-3.00 a.m. (…) That is why it could only happen when you make sacrifice. (P8).

While this is the case in that school, another school principal stated the opposite behavior as

> "When you show them with concrete examples how it is important, but still she/he does not want to be involved in the process, then you need to respect his/her decision." (P2).

Another one stated the undertaking of both success and failure as a team with teachers (P4). That also shows how the schools are not ready in both awareness and taking a role to apply STEM education since it could not be the first option to apply in the schools but requires effort and time out of the school to implement.

Those concerns show the obstacles to implement STEM education related to the school context and the lack of readiness. Yet, the description of the data was done superficially in this section and the analysis of the data will be widened in the following section by content analysis. In the following section, revealed results are gained by coding the data collected and separating them to the themes emerged. Thus, the issue will be analyzed to deeply understand the perception, experience and role of the school principals.

4.2 Content Analysis

This part of data analysis constitutes a typical content analysis with coding, identification of the themes, and categories in order to form a conceptual framework helping to interpret the data with organized and meaningful way to the readers (Yıldırım & Şimşek, 2005). In this section, the themes, and subthemes emerged from the data and organized are discussed under the three research questions. There are nine themes in total formed to try to understand the perception of school principals about STEM education, their experiences in school in STEM practices and their role in STEM education.

The first research question is interested in "How do the school principals in high schools perceive the educational trend of 2010s 'STEM education'?" and there are four themes coming up: (1) definitional issues for STEM education, (2) STEAM vs. STEM, (3) contribution to Turkish context, (4) gaps in STEM education. For the second research question, "What are the experiences of school principals in STEM

Table 4.1

Themes and subthemes emerged from data

Research Question	Themes	Subthemes
RQ1 Principals' perception of STEM education	Definitional issues	• Artificial intelligence, robotics and programming • The interdisciplinary approach of the STEM to learning
	STEAM vs. STEM	• The importance of arts and humanities • Its advantages over STEM education
	Contribution to Turkish context	• Educational context • Individual development • Contribution to Economics
	Gaps in STEM education	• Social justice and STEM education • Curriculum gaps • Incongruence between educational system and STEM education • Educational context • Lack of know-how and funding for STEM education
RQ2Experiences of principals with STEM education	Background of the school	• Students • Teachers
	STEM practices in schools	• TÜBİTAK projects • 3D printers, projects and innovative implementations
RQ3 Principals' role in STEM education	Facilitator Supporter Motivator	

practices?" there are two themes emerging as (1) background of the school (student and teacher characteristics), (2) STEM practices in school. In the last research question "How do school principals define their roles in STEM practices at their schools?"- the themes appeared are being facilitator, supporter and motivator. Considering these themes, the emerging issues about the research questions will be discussed in following sections. The themes and subthemes are represented in Table 4.1.

4.2.1 Principals' Perception of STEM Education

In order to answer the question "How do the school principals in high schools perceive the educational trend of 2010s 'STEM education'?", we need to understand conceptual issues emerged in principals' thoughts, their comparison of STEM education with STEAM education, the contributions of STEM education to Turkish context regarding to their opinion and lastly the gaps that STEM education could create. The themes and the codes were taken from the repetitive issues emphasized by the school principals.

4.2.1.1. Definitional issues of STEM education.

Definitional issues of STEM education are the first emerged theme regarding to the perception of school principals. There are differences among school principals regarding how STEM education could be defined. This theme is not the definition of STEM education but definitional issue because of the lack of knowledge and misconceptions of school principals as indicated by one of the principal highlighting the definitional issue by combining it with Turkish context by saying:

> STEM is not an area I have a grasp of although I have thought and read about it a lot. I think that STEM education is not defined completely and clearly in Turkey. It seems that it is narrowed to the context of robotics area. (P1)

In addition to this indication, there is another principal stating it as a life philosophy.

> I think STEM could be applied to all areas if it is a technology then this technology should not be restricted to only physics, chemistry, biology or mathematics. The mistake we do is in this notion. We need to apply it to other fields. If you give education with this notion then you could not turn it into an implementation but you have a new theoretical course just like physics, chemistry, biology. Then it does not serve to its goal.

> In my opinion, you can arrange STEM education to be a life philosophy. Thinking it in this regard, even a housewife could do miracles. (P10)

Although some of them have an opinion about STEM phenomenon and search about this phenomenon, while interviewing the school principals, it is observed that there is not much knowledge about this "educational trend." One of the school principals stated that,

> I do not have much knowledge about STEM education but it could be related with science, mathematics and even physical education. (…) It is harmless to try new teaching methods that have a proof of efficiency over the currently used ones. (…) Science, mathematics and engineering fields are not far away from each other. In fact, they are interwoven (…) and if this educational practice means visualizing, adapting and accommodating the knowledge then it could make sense. (P5)

Even though the principal does not have the knowledge about the STEM education, for him it sounds like a methodology that could be applied in the classrooms.

In addition to the general definitional issues of STEM education, some of the school principals pointed out the relation of STEM education with artificial intelligence, robotics and programming by seeing STEM education as an aim to teach artificial intelligence, robotics and programming.

One of the school principals (P4) stated that "There is a tendency to education in the areas of mechatronics, and robotics that have a side of raising the intelligence" by mentioning STEM education when it is asked. Apart from this principal there is another principal who emphasized that:

> Abstract intelligence especially artificial intelligence and software revealed that educational practice. I think that students should be educated in artificial intelligence field especially in this new age. (P1)

In addition to the interviews there is also supporter indication of given importance to programming, software and information technology in document analysis especially in the web sites of the high schools. Those include both implementation in school and the announcements for students to apply outside of the school.

The notions indicating the connection of artificial intelligence and robotics with STEM education are also indicated and studied in the literature. Parallel to the literature, the participants highlighted this issue as one of the definitional problems in our results. Hence, the confusion on the definition of STEM education indicate epistemological gap for the bases of STEM education.

Apart from the principals understanding of STEM from the robotics side, some of the principals see it as an interdisciplinary approach merging the fields referring to the acronym. One of the principals indicated that "STEM education is useful to compound what they have learned; it is to reveal the complete learning." (P8)

In addition to this thought about STEM education, there is a principal emphasizing his opinion about STEM education by using his experience with his mechanical engineer son.

> Before going further about our school I can say that my son is a mechanical engineer and his job requires to know and combine different aspects of science. So he has to know chemistry, physics, mathematics and technology and use them all together. From this point of view, I think STEM education is a positive and contributing movement. (P7)

In document analysis, there is no sign of an interdisciplinary movement in the schools seen neither in the strategic plans nor in the web site announcements.

All in all, definitional issue of STEM education was pointed out by school principals matching with the literature. There is conceptual chaos for STEM education which also creates confusion for school principals in addition to their lack of knowledge. Also as observed during the interviews, STEM education is not something fitting into a place without any example. Some see it as their traditional teaching and learning environment in their classrooms while others think that it needs an infrastructure and budget to implement as robotics and programming. Because people in the area have no consensus on definition for what STEM education is, the concept fails to fit any commonly agreed definition. That is why school principals flit across with some definitions not fitting any sensible foundation.

4.2.1.2. STEAM vs. STEM

During the interviews, when it comes to the STEAM education that revealed after STEM education against the notion of excluding arts and humanities from an interdisciplinary approach, there were different opinions about it among the principals. While some of them supported that it could be implemented, some thought that it is hard to imagine all together in an educational practice. One stated that "I do not think that different fields could be added to STEM education. It could not happen in practice. How can you add humanities into science? It could not be added" (P3). On the other hand, one of the school principals emphasized that "…not just in scientific areas, but the improvement should also realize in national and moral values, sports, arts, cultural values. They could not be a lack in education" (P8). Another principal supported that notion by stating that

> There is definitely a contribution. Without drawing, physical activities or music, the life could not be imagined. The development in the aesthetic aspects of humans and making studies on this issue is necessary. (…) Having a package including STEM fields all together with the arts and humanities is a right thing to do. (P7)

However, combining STEM areas with different social science areas is a question mark for one school principal.

> … There could be an absolute connection with geography and STEM areas, with history at some point there would be a connection. Literature, literate thinking and splitting your thoughts into the pen I don't know. That is a question mark. (…) the fields requiring thinking, or directly connected to think and their connection with STEM. I rather to take a pause. (P5)

As it can be seen from different perspectives about the issue we can say that it is a controversial area for principals whether STEAM can be applied or not. However, there is a commonality in their notion that arts and humanities are required for individuals' life and they need to be integrated into educational contexts.

Either as an integration to STEM education or as by themselves, the importance of arts and humanities is indicated by the school principals. Before mentioning interviews, the documents analysis shows many proof of arts and humanities applications in the

school. Trips, exhibits, theater performance, the annual literature magazine of schools, symposiums, cultural competitions are announced in the web sites of each school. In addition to those, school principals also indicated the importance of arts and humanities as one emphasized "…humanities are important. Conscience is the own police of each individual." (P4). The others expressed their applications in school as

> Personal exhibitions are opened to the students having talent. This is an application we see in private schools and implement in our school. Students with musical abilities have concert at the end of second semester. We have a literature magazine published by our students. (…) (P3)

> We have theater club for 24 years in our school. One of the state artists works with our students and they play displays in the state theater scenes… Our students do not end their music course without learning to play any instrument if they choose music as an elective course, even it is flute or darbuka. (P9)

Other than those, there is one principal highlighting that "I care about the activities like debates, panels, symposiums that let students express themselves " (P1). As their importance all alone, some principals also indicated how STEAM is more advantageous than STEM education since without the integration of arts and humanities, STEM education is not right movement to do. hey express their notion by saying:

> After the industrialization, there are lots of inventions done in the world in the 18th century. Especially when you look at the 19th century, with the positivist paradigm where those have its roots, capitalism did the same thing too, the human remain in the background. In every movement, technology brings money into the forefront, that is what STEM does too. They realized that the dimension of the situation was changing after saying what we have done to humans. Technology is not everything. There are humans inventing this and using this. Technology does not rule us. (P10)

> In the future, robots will do the surgeries, work in machinery sector but leading the way of the society will be the individuals equipped with the merit of being human or at least we will need those individuals. When this is the case, I absolutely adopt STEAM education. maybe it is not STEAM education what we are doing in our schools but approximately 70% of our studies are social activities and we try to raise individuals who happily live in the society. (P1)

Therefore, for the STEAM education, the principals have a support that brings the holistic perspective into the surface where being human is about integrating STEM with arts and humanities other than the principal who has misconception or lack of knowledge about it.

> We need to think human as a whole. Human is not the individual who only works in scientific area or has wish to learn only scientific knowledge. Thus, while doing studies in scientific areas, she/he could be interested in music, doing sports or working in social areas. Education is needed to be seen as a holistic thing which was already as this way in the world. (P6)

Since there is no sound epistemological foundation formed for STEM education, it creates a confusion about what it is, how it can be implemented, what it is related to, and so on. Therefore, STEM education does not fall into place in the principals' mind originating from lack of foundation. This makes STEM education a trend just referring to scientific studies interested in mathematics and science only in the eyes of school principals and other individuals. Education is something to have a holistic approach while raising both human side and intellectual side of the individuals to be prepared for future. That is why STEAM education is seen by school principals as something advantageous over STEM education. In addition to this some of the school principals consider their difference as being the ones creating teaching and learning environment for scientific learning which forms their school culture. There could be an ongoing tradition that affects both the decisions of the students and the actions of the teachers such as being a science high school or being at the top of the high schools in the district disregarding the arts and humanities aspect of life. One of the school principals stated that

> "Science high schools and the project schools tend to give importance to science and mathematics fields and teach subject around those fields. Traditionally our graduates should be doctors, engineers in any case." (P9).

The school culture in high schools is mostly formed around the notion of preparing the students for the future with scientific equipment and being volunteer to make changes in their lives or attending to projects and activities for teachers.

4.2.1.3. Contribution to Turkish Context.

Despite its definitional issues and comparisons with the STEAM education, principals think that there are still contributions of STEM education into Turkish context in educational context (1), individual developments (2), economic (3).

Some of the principals underline the importance of STEM education in this century in economics matching with the literature, some see them as an opportunity for students to individually develop. Also its contribution to educational context is also mentioned by some. Although some of the school principals have an opinion about STEM education, some of them did not hear about the concept before the interview. Therefore, those who do not have prior knowledge about STEM education talk about the contributions of STEM education hypothetically by comparing it with former policy changes in educational system in Turkey. One of the school principals in that regard stated that

> If it was in the thinking phase, I absolutely approve the effort to try it. if I tried, then I would absolutely approve the implementation. On the other hand, there is a situation that every idea is good in the thinking phase, when it comes to implementation, we need to look at the results. If the results are efficient, then it needs to be applied. (…) as I heard the concept from you that helped me to form an opinion about it, I believe it will contribute. As a nation, we love the transition from theory to practice. We do not put the knowledge in our head if it is theoretical. (…) Therefore this system fits into our spirit. (P5)

Another principal emphasized its contribution to analytical thinking.

> We you look at it, there is an ability of analytical thinking. This is included in mathematics and in science groups as well. Analytical thinking is valid for all numeric fields. If you look at geography, there are natural phenomena. In history, students need to think analytically and make comments. So you can adapt STEM education as an educational material. It seems mostly incompatible with literature, but you can find a response in there too to STEM education. (…) If you say I want to look from all angles or approach the circumstances interdisciplinarily, then it will be different. What I mean is that the perspective of an engineer to the sociological issues or societal situations is different. When you look at the situation with an eye of engineer, it fits into mold but the perception of an historian is a plain logic. So the view of life is restricted in that sense. Therefore, STEM

> education includes all areas. You decide the scope where it starts and ends. (P10)

Apart from this notion, there is a principal who thinks that STEM education contributes to problem solving skills in addition to analytical thinking.

> STEM, especially in laboratory and implementation classes, offers good things to students to face with a problem and solve it. Secondly, analytical thinking. For example, with a 3D printer, first the student thinks about what to do analytically, then she/he forms a schema in his/her mind, draws the image analytically, then reflects it. Those are all about STEM education concretizing things offering students good and big opportunities.

In order to emphasize the advantage of STEM education for putting knowledge into concrete base, another principal stated that "Students benefit from STEM education to convert their theoretical learning into practice. That provides students with the opportunity to reach the goal of learning." (P8) In addition to analytical thinking and problem solving skills, one principal mentioned that "STEM education brings holistic approach, providing holistic thinking for students" (P7) Those are their opinions about the contribution of STEM education to the educational context. Despite the contributions, there are gaps formed by STEM education according to the principals which is the topic of the other theme of principals' perceptions.

In addition to the contribution of STEM education to the educational context, STEM movement is perceived as a contributor of individual development for some school principals. One of the principals emphasized its contributions to improvement of students in social context by stating "STEM education not only directs students to use their intelligence in the courses but also in the social and societal life to improve their communication skills."(P9). The same principal also indicated its contribution to entrepreneurship and self-confidence. He said that

> STEM education helps them to gain self-confidence. When they get success, they gain self-expression and the ability to defend their project. It adds the entrepreneurship to their personality. For example, our students meet with the companies for sponsorship and they show their willingness and entrepreneurship to do this job. They communicate well. (P9)

Apart from this opinion, one of the school principals looked at STEM education from the perspective of technology and entrepreneurship and some attempts for our youths to be the part of competition in the world in this area.

> Hamdi Ulukaya has an attempt about supporting the skillful youths who are entrepreneur as well to provide them education in Unites States of America and send them back to Turkey. That means there is an awareness and the salvation of our country is in that direction but there are not enough studies about it as it has lack in media as well. Our startups are a few. (…). Yet it looks promising. (…). I believe in you. (P10)

The indication of entrepreneurship takes place when it comes to STEM education contributions for them. Although entrepreneurship is the skill to start a new business especially for chasing the opportunities in the economic field (entrepreneurship, n.d.), just one principal indicated the economics dimension of STEM among the school principals talking about the contribution of STEM education to the entrepreneurship. The emergence of STEM education because of economic reasons is also mentioned by him. Apart from him there was no one looking at it from that perspective which is highly indicated in literature as well. He is the deputy principal in the school where "garage" is established inspired from Apple and Steve Jobs and Steve Wozniack. He stated that

> When you asked about why everyone goes to United States of America, it presents opportunities. When presenting opportunities, it says I invest in you 50.000 dollars and how much I will get in return. It is totally trade. Education is unfortunately a trade, so is STEM. (…) When you think about Apple, they established it with a limited budget, with a support of investor. Then suddenly it gets in the top, and then the company was taken away from Steve Jobs. The point we are missing as a country is this. We could not turn what we found to be in trade market. (…) When you look at the news you see that in Black sea region, in Trabzon, our people do the staff without any educational practice what the United States of America do in STEM education. Yet they are not aware of it. There is no entrepreneur. If you give STEM education, you have to give entrepreneur spirit. You need to turn it into patent. Turn it into patent and sell it, make money. You will end up being the one of the richest people in the world suddenly or you end up broke. (P10)

4.2.1.4. (Policy) Gaps in STEM Education

Even though STEM education may contribute to economics, education and individual development according to high school principals, this movement also has some gaps in the educational context because of the policy transferring issues and related subthemes to policy gap.

The policy gap forming an obstacle towards implementation of STEM education is expressed by school principals. There are different codes coming out for this subtheme as the differentiation between public and private schools, gaps in regulations and applications, deficiencies STEM creates, reaching the experts of the field, and finally the issue of reaching school materials any time.

In general, about policy gap for STEM education one of the principals stated that

> "In opening speech of a congress, professor said that after the establishment of Turkish Republic, MoNE did many reforms and changes but unfortunately those reforms did not take place in the classroom environment. I experience this for 20 years by myself too. (…) STEM education has the same too.
>
> (…)
>
> Education has another side that education has an ideology. Every country, every nation wants to raise their students. United States of America is different. Since its establishment, it takes the 35% share from the global education. It gives opportunities to the most intelligent ones to get them in the country and it wants them to gain a sense of belongingness. Therefore, it is valid them to start an action as STEM. Okay, STEM education could come to our country but it has to be in our country not transferred from United States of America. There are some attempts about this for two years but it is still in thinking phase. There is not implementation unfortunately. (P10)

Also one of the school principals emphasized that

> Lastly, FATİH project, when we criticize the examples in it, there were no students and teacher in a classroom environment who lead the process as it is in a computer and technology laboratories. Therefore, we could not say this was a success. Why? Because there was lack of content. The tablets should be filled. (P2)

Another criticism about STEM education is that this movement is seen as the only savior which could save us all.

> STEM is not very well understood idea, unfortunately. I read a lot, think a lot about it but I could not learn even 1% of the whole STEM education. We do the same mistake and direct in one direction hoping to save us. However, human being has a complex structure and has a complicated brain that one direction could do anything. Therefore, maybe STEM education could be useful as a tool in the educational system to raise individuals but it is not safety buoy by itself. (P1)

A principal from another high school stated that:

> The matter is that there should be a systematic operation in education. There is a metaphor saying 'attack a meal like a ravenous wolf'. We should not come close to everything that is implemented by others or we heard. Unfortunately, MoNE approach STEM education as some other issues with that approach but everything does not fit to everyone. (P8)

This idea is supported by another school principal who gave the example of 1990's popular management approach tried to fit in our system, which is Total Quality Management (TQM). The principal stated that "When we met Servet Özdemir after years he tried to adapt TQM into Turkish context, he emphasized he better gave it up and it could not be applied to Turkey. Therefore, if STEM education comes from United States of America, then it is not a good method."(P3)

In addition to those general notions about policy gap, policy development gap of STEM education, there is social justice issue of STEM education related to policy gap. When it comes to the difference between public and private schools regarding how STEM education can be applied in educational environment, some of the school principals thought that they have source, different applications and chance to apply perfectly. One of the school principals stated that STEM education could be implemented in a few public school apart from the private schools:

> When it comes to the establishment of computer centers and robotics workshops, we could not go further. Our biggest drawback is that there are a few public schools who can do it apart from the private schools. Those who can do get help from companies to set up this STEM environment. There is a huge financial burden coming with STEM education. (P1)

Another school principal pointed out the curricular activities going on in private school as “I examine some of the private school curricula and they produce technological programs” (P6)

Apart from those, one of the school principals gave example from FATİH project and its application in one of the private schools as “I observed in a private school that our English teacher uses this technic now. (…) I observed how they use those materials when they teach English to students. I admired it. (P3)

Therefore, school principals have an opinion about the opportunities and advantages of private school over public schools when it comes to STEM education. That is why there is a social justice issue revealed because of the advantageous terms of private schools with their infrastructure and additional human sources helping them to fit STEM education into their practices.

In addition to the social justice issue of STEM education, there is a concern about the curricular practices regarding the integration of STEM education. The question “How can we apply STEM education in our schools?” is a question mark for school principals because of the curricular reasons. One of the school principals summarized the situation by saying “When you say that I will do this in science fields, there is a university entrance exam, curriculum issue and teacher issue” (P10). The support of this notion comes from another principal stating that “As a public school, we have a tied regulation and curriculum we need to follow. Therefore, there are no any applications other than those done in other schools” (P7). Except from those opinions, there is another one stating that “Is it possible to learn physics, chemistry, biology or mathematics better when we apply STEM education? I don’t think so. It could not respond to all the needs.” (P3), which is about the deficiency of STEM education as well.

Another school principal stated his concern about the mathematics teachers even though there is M in STEM representing mathematics by emphasizing that “I think the mathematicians are not much involved in STEM, I could not find the answer to where they should be in STEM education. Maybe it is also because of the curriculum not creating environment for them to be involved.” However, he also states that “Our

curriculum is valid for this educational practice. We have many application courses but we need to design courses with a new and different lab environment." (P1) This notion is supported by another school principal who specified that "We call 'the system' but who defeats this is the teachers and administrator. MoNE tell us what to teach, it is true, but it does not say that you need to drill with tests (do a test)" (P8). Another supporter says that "It can be applied in Turkish educational system since the system is not far away from those practices." (P6).

Besides of those curricular issues regarding STEM education, there is another gap which is created by STEM itself in education according to school principals, which is the incongruence between Turkish educational system and STEM education. The participants illustrated the conflict between different functions or structures of the system and STEM education.

Although there is a support for STEM education among school principals, they also think that this educational practice could not respond to all the needs and requirements in the educational context. As mentioned earlier some think that human being has a complex structure that s/he could not be educated with one and only approach as STEM. Another school principal stated that "You consider education as a whole. When you want to expertise in social or scientific areas, you can gain it with university level education. Administrating the schools and the curricular activities just around STEM education is not a valid approach." (P6). Another school principal explains the deficiency by emphasizing that "Life or the school is not just about science and technology. 'I will teach just STEM and leave the rest' approach is not appropriate." (P7)

Except from those, one of the school principals quoted from the Minister of National Education, Prof. Dr. Ziya Selçuk, that we need to teach our children the things to take place in the future which robots cannot do. (P1)

Apart from those there is different emphasis on the lacks that STEM education leaves by other school principals stating similar ideas with the ones quoted here. Therefore, it can be said that relying on just one approach seems inappropriate for school principals to apply as an educational practice.

In addition to the incongruence of Turkish educational system and STEM education, there is a need to understand the educational context as well. When STEM applications and the experiences in a school are the case, we need to investigate whole educational environment by the information given by school principals and document analysis so that the STEM applications in this environment could appear. While the school principals were talking about the educational environment in their schools, they mentioned the physical environment, the different applications in their school separating them from other schools, the foreign language education in their schools, the teaching methods used by teachers and the individual development activities done in the school including arts, humanities and traits that could lead them to good places in the future as entrepreneurship as they indicated. When it comes to the STEM education and the educational context to present this education, principals indicated mostly that there is no STEM application in their school because of different reasons. As mentioned earlier in the "Teachers" section, one of the reasons is the lack of knowledge of teachers. One of the school principals clearly said that "We do not have STEM education in our school. (…) Our teachers try to implement but we could not apply it to the classes" (P1). Additionally, one of the school principals emphasized the importance of in-service training for those kinds of implementations stating that "In an unknown subject, you could not do much of work and production, and be productive. We need to know first. That is how you could not have opinion without knowledge, we need briefings in our schools about STEM education." (P6).

Another school principal indicated that

> We except something from the students in STEM education but in our schools it could not be applied since the students mostly come from far distance. Where can it be applied? In a boarding school. (…) There are limited applications anyway. You need to announce those to each student, we try this by hanging the competitions on the walls, we say it directly. Students do not give much attention. They have the ability but there are so many side effects interfering. (P10)

To sum up, there are different applications or none in schools related to STEM education. the general notion is the need for training and briefing about STEM education and support to create environments where those could be applied. There is

a lack of knowledge and physical sources to implement STEM education in high schools.

The gap that most of the school principals are agreed on is the university entrance exam taking place in the 12th grade after four years of high school education. They specify the needs and claims coming from students and parents in the last two years mostly in the last year of high school because of the wish to prepare for university entrance exam. There are stereotypical choices determined for students who study in those schools chosen as sample in this study. One of the school principals is also indicated that as "Science high schools and project high schools go towards in science and mathematics areas and weighted education is conducted in those areas. Traditionally, the graduates of those schools particularly become doctors or engineers." (P9)

Also, the other issue here is how the school success is measured by the university entrance exam results. While one of the principal stated that "Our school's rate of placement to the university is high" (P7), another principal defended that "If we concentrate on the placement of students into universities, and their degrees in the standardized exam, all of our 100 students could have a degree in top 500 or 1000." (P8). However, they prefer not to do so. Also one of the school principals said that "When students become distant from the school in their last year, they regret it later in their life." (P4). The indication of stress level in students is another problem caused by university entrance exam which does not let teachers implement the curricular activities in the last year of the high school. Because

> Students could say "please do not teach me those, I want to drill test for the entrance exam". They do not want to listen literature especially when they are in science classes. Especially in the last two years, that is what we are going through. (…) University entrance exam ruins the country and does not leave space for analytical thinking (P3)

Apart from the claims of students, there are parents, who want preparation of their children for the entrance exam.

> You face with a dilemma here. There is a university entrance exam and the parents want their children to be prepared for this exam. (…) They want their children to drill in the evening at home. (…) getting good

> result from the exam, going to the specified university and program creates the dilemma for us (…) (because) what the parents want and what teachers give as an education is different from each other (P10)

Therefore, university entrance exam is an obstacle towards the teaching and learning environment where the applications as STEM could not take place according to school principals.

Other than that in those schools, future generally means the university entrance exam and it is life itself for some school principals. The measurement of being the best school is the achievement in university entrance exam and having students in the best universities of the country, therefore school principals give importance to that aspect. They indicate how students adapt themselves to this exam and ignore the school environment as emphasized in previous sections. Therefore, there is a need to adapt those students to school rather than the exam and the teachers are the key factors. That is why all teachers should be involved in the process of raising students for future. However, this STEM education process could only be done with the support and sacrifice of teachers since they are the ones responsible for the teaching and learning process. Being a teacher is an important job which could also go in wrong ways as a school principal in science high school had a statement indicating his concerns about raising the students as "Teacher should not be the person imposing his/her own truths to students. (…) Students should go ahead from us. The teachers should not create their clones but they need to set students free." (P8).

In addition to the educational context and its relation with the gaps for STEM education, there is a need to discuss the lack of know-how and funding for STEM education. Lack of know-how and funding for STEM education have been found to be among the gaps in STEM education. The lack of know-how has emerged as a gap since there are some obstacles in implementation process of STEM education. Firstly, the principals need outside sources as experts to support the projects to be run in the school under the application of STEM education. Since there is a lack of the knowledge for how to support students in the projects, they are taking support from the outsiders as universities and engineers. When doing a project, students could need expert opinion that could lead them through the process where teacher, peer and principal support could not take the way of running the project and there is a lack of know-how. This

kind of support could be from companies or university professors that school administration communicates with to get their expertise. Even though they can reach the experts as schools, their connection unfortunately takes place in short terms. A principal pointed out that situation by saying "We could have problems in the long term communication with the experts of the fields but we can handle the short term communications." (P8).

Also another issue about the lack of know-how is how STEM education could be implemented in the time of curricular activities, because of the fact that STEM education could not be integrated into the curricular activities, there is a need to create time for students to work on the projects that could lead them to be in STEM related processes. Yet, they could not find time and they do not know how to solve this problem. Therefore, there emerges another issue regarding the times that students could reach the school sources. Because of the fact that the schools are open in restricted time before and after classes, it is hard to reach the school materials when needed. Therefore, the need is indicated by the same school principal as "Actually we have an intention to keep the school open 24 hours a day with the support of guard. If the students want to study on the projects they are doing, then they could be up all night to study." (P8). This school could have an opportunity for this intention because there is a complex surrounding the school and it has facilities as dormitories and sports field. However, the school without this surrounding do not much opportunity to keep the school open for 24 hours. For this reason, another school principal stated that

> There is a need to create time for students. They need to have time to try things in labs and "garage", they need free time to attempt. Steve Jobs did not work in daytime, they studied at night in this garage. They make use of their free time. (…). If this school was a boarding school, I could activate the labs, and I could apply the best education with the support of our two or three teachers. (…) When students meet their basic needs after the classes end (03.30 pm.), they will enter the laboratories voluntarily. When they do this voluntarily, they do excellent work (P10)

Thus, there is indicated requirement of the full time access to the school supplies to let students work with a variety of sources in a school environment. Those two issues emerged for lack of know-how were indicated by only two school principals who also are the only ones mentioning STEM education implementations in their schools. In

addition to the lack of know-how issue in STEM education regarding lack of knowledge and the available time contradiction for STEM education, the funding to support STEM education is the issue about financial gap requiring to be filled. Therefore, every school has different approach about this situation but there is a common notion that the extra budget is needed for extra expenses done for the educational practices except from the regular spending. This extra budget is provided to schools from different sources such as School- Parents Association, companies, universities and non-governmental organizations. About creating budget for STEM education, there are still financial drawbacks. One of the school principals stated that:

> The biggest drawback of STEM education is that it is an expensive movement. This forces schools mostly. Schools could handle only the regular spending. In an environment where a 3D printer costs 10,000 liras, a STEM lab will cost over 200,000 liras. That could be met with a large budget as the state has. Except from this, the materials for robotics, especially software as computers and the programs are expensive. We could not provide those opportunities to every child or every student. Therefore, for STEM movement, in this high school, we could not go any further from the setup of a computer and technology lab and basic robotics and robotics workshops. (P1)

This notion is also supported by another school principal who mentioned taking financial support from out sources as well.

> We do not have enough sources. We provide financial support from non-governmental organizations. There is 90% lack of fund but we do not make this an excuse. (…) When our computer is not good enough, we take our students to the place where there are expensive computers if it helps them to study. This is a sacrifice. (…) By being raised within this system, our students become managers, engineers in the future. Therefore, the companies in the economy in those fields should support the system. The companies expecting good job should consider the qualified job is done by qualified individuals. They need to invest to education for that reason. (P8)

Apart from those notions, there was a principal thinking that -the financial support for STEM education should be provided by stating that

> "Yes, there could be some drawbacks about finance in schools but it is not true to attach everything to financial obstacles. Yet, in that kind of scientific activities, the support is provided as money and there are some drawbacks about it." (P6)

In addition to those opinions, in general, the financial obstacles of schools were indicated by other school principals as well for all of the educational activities.

4.2.2 Experiences of Principals with STEM Education.

The second research question of this study is "What are the experiences of school principals in STEM practices?". In order to get answers for this question, we need to understand the background of the school that is indicated by the school principal including teachers, students, school principal himself/herself and the educational context. Other than background of the school, there is another theme which is the compatibility with STEM applications in which the implementations in the school regarding to STEM applications will be discussed.

4.2.2.1. Background of the school.

Every school has a different climate and the internal stakeholders fit into this spirit by time. The school principals interviewed are working in the top schools of their classification in Ankara and in Turkey. Therefore, in those schools teaching and learning environments let the students and teachers open to be to new practices, projects, and experiments because those are categorized as project schools as well by MoNE. Therefore, their vision statements mostly include the statement of "being the best". This is because of the quality of students in those schools who entered by the high school entrance exam scores. The teachers and school principals should fit into the pace of students in those schools because of that reason.

The students' academic quality is indicated by almost every school principal as an influencial factor in educational environment. One of the school principals mentioned that situation by stating that "The students are qualified, have potential, high knowledge level, and enthusiasm in the participation to the activities." (P9). Another school principal added the readiness level of the students as:

> Actually, the students are ready for STEM education. Especially the students we are working with in this school already learned about computers, programming etc.(…). This generation is willing to and familiar with the STEM education. Even the least knowledgeable one has the capability of doing a little programming to solve their problems

> on computer. Especially the activities that we could relate to STEM education in our school, programming and robotics classes supported by computers attract attention of students. They enjoy it. (…) There is a ready crowd of students and they are enthusiastic about it. (P1)

Another principal highlighted the importance of student qualification by stating that

> The thing that raises the quality of the education is the student quality. Therefore, we can describe our education as very well. (…) The difference come out with the student quality. Teaching the same topic in a village school and here is different. This difference is because of the student. Since there is a level difference between the students, the level of the teaching changes as well. (P7)

When one of the school principals described the educational environment, he mentioned that students are curious for and enthusiastic about STEM.

> The educational environment is active. Since the students are curious, they try to reach the subjects that they are curious about from different sources. They reach information from their teachers, communication sources and universities. (…) The difference between the other schools and this school is the communication between students. They teach each other in this school. By sharing, the teams enlarge, and the circle expands. There are students who do not want to go to the classes to study on STEM subjects. (…) They could go beyond us in different subjects. They are knowledgeable. They want application instead of theory, they enjoy application more. The reason why the application in this school is different is about the student group. (P8)

One of the school principals stated that "they need to be motivated for STEM practices" (P10). Apart from those stated, one of the school principals stated that the students are academically successful, but they need to improve their social side too and this is what he is mostly interested in. (P11).

In addition to those, the satisfaction of students from the educational environment in schools was indicated by different school principals. When documents are investigated, there was different news about students and their achievements in painting, music, literature and in TÜBİTAK projects they did with their teachers, but not in STEM fields.

When talking about the students regarding the STEM practices in the school, we need to indicate the teachers and their applications in the educational environment because

they are the ones who do the educational activities. They are the ones actually taking the lead in the teaching and learning area trying new things. One of the school principals stated that. “There is no implementation (of STEM education). Maybe, it could be implemented since an interdisciplinary approach could work but it requires the groups of teachers to work together.” (P9). When it comes to the participation of teachers in the applications, the same school principal specified that “There could be some teachers who do not want to participate the studies, projects or activities. They participate in the actions about the classes necessarily but for a plus work, the volunteerism is needed. We work with the volunteer teachers.”

Another principal stated that,

> Because we could not change the teachers, we degrade courses to only classes. (…) We told teachers to go out from the classroom environment, at least to have a living space. Shift learning to the out of classrooms. (…) We insist in it but there is a drawback which is teacher education. (…) For example, they need to construct knowledge (for the constructivist curriculum came to the education system in 2005) but any teacher could not do that. Since that day, there have been a few teachers doing that. Even this approach was not being implemented. (…) If they implement STEM education, teachers need to put effort not just in the classrooms. (…). When it comes to the point, sometimes, two teachers could not prepare a mutual exam. (…) This teacher could not compromise other groups of teachers as well. (…) We are kind of individualistic here. There is no team spirit. We could not handle it. (…) For this garage we wanted to give in-service training to our teachers. The educator who gave the training was an IT person, directing teachers or telling them what to do by saying “Do this, do that.”. I told him “Do you believe that you could teach it to teachers?”. He said he believes but teachers could not login to e-mail for half an hour. (P10)

Another principal indicated the need for in-service training for teachers by emphasizing that

> Teachers are the part of this goal (i.e. STEM education). Not every teacher could have capableness for computer and computer based courses. Therefore, STEM education could not be understood by teachers. So, how they could teach physics by using STEM? There is a need for in-service training for teachers with many samples. (…) Apart from this there is no problem with willingness and dialogue. (P1)

Despite the fact that there is no STEM practice in the school, one of the school principals stated that this educational practice could be done with the experienced teachers by saying:

> This type of study needs to be implemented by the experienced teachers, so that it could be more valid, in my opinion. Since we abandoned the teaching dimension long time ago, a wider opinion could be taken from teachers about how this practice can be attached to the educational environment. (P7)

In addition to those, one of the school principals emphasized the group work of teachers about learning from each other. "The teachers get help from each other about STEM or anything they have question or have no knowledge. 'I do not know, ıf you know, could you help me?' approach is dominant here." (P8). Another principal stated the motivation of teachers about this as

> "Physics teachers are motivated about STEM. Last year they built a cooler in our school and it was sold to Ülker. (…) The group of teachers started to work together, they got rid of individuality slowly." (P4).

Moreover, there is a school getting in-service training for their teachers from YEĞİTEK about STEM education in the summer seminars. The same school principal also stated that "There is a need for teachers who could inform people and activate people about STEM education in schools." (P6) Therefore, there is a commonality that the teachers need training about STEM education to apply this educational practice in the schools.

4.2.2.2. STEM Practices in Schools

As stated in the first section above, the STEM practices are very limited at the schools that were investigated. Although there are not any concrete application examples in schools regarding STEM education, there are still implementations that could match with the STEM education for school principals.

The one practice stated by all school principals is TÜBİTAK science projects and competitions which lead students to think about problem and find a solution for it. In all schools, the principals indicated their projects by linking them with the STEM education. They have news and announcements about their application and

achievements in TÜBİTAK projects in physics, mathematics, chemistry, programming, philosophy, history as taken from document analysis. Those are not the teaching and learning environment created for all the students but those studies are the one done by chosen students interested in making projects with the support of the teachers and also professors from universities to be prepared for the projects. While one of the principals emphasized that "There are approved TÜBİTAK 4006, 4007, K1, K2 projects that the students have individually in our school." (P9), another school principal stated that

> When a student comes and say I want to prepare a project for TÜBİTAK, we match the student with professors in universities and there is a TÜBİTAK Olympics group in our school. They gather at the weekend and on weekdays in labs and the rooms reserved for them to study with the materials. (P5)

Therefore, collaborations and the implementations for TÜBİTAK projects are extensive in those schools which could also be because of being project schools and science schools.

Other than TÜBİTAK projects, the emphasis of having 3D printers is another thing that seems as STEM application tool. Therefore, whether owning one or not, they give 3D printers as an example of STEM education which is mostly combined with the robotics and programming activities as well. "3D printer is a quite different field. It opens very serious experience field for students, it is a new field and it contributes to STEM education or technology." (P1).

In document analysis, it is seen that there is an interaction with successful Turkish scientists in NASA, and Cambridge University. Also, there are applications in some schools regarding organizing robot competition (P8), artificial intelligence competition (P1), and activities about programming week (P6). There is a school where there are applications under the name of STEM but the school principal did not mention those and did not have much knowledge about STEM education. There is an e-twinning project of the school called as "From Scientix to STEM" and there was a trip to STEM&MAKERS festival but he mentioned in-school competition regarding innovation. (P11)

One of the school principals stated that "We wanted to equip a place with multi-dimensional printers and computers for studies about robotics and paving the way for new inventions but it is not activated yet." (P9). The principal from one of the science high schools stated that "As I mentioned, the students have studies contributing to STEM applications, they study on drones, and projects. We provide expert support to their studies from industry and universities." (P8). Therefore, there are studies about robotics, programming, 3D printers and innovative competitions that are reflected as STEM applications by school principals.

4.2.3 Principals' Role in STEM Education.

In order to answer the research question "How do school principals define their roles in STEM practices at their schools?", three themes emerged. Those themes are related to the traits of school principals emerged as they indicated for STEM, which leads us to know about how they direct and lead the way of STEM education. The principals have different roles in order to run the implementations properly. For STEM education, participants indicated some aspects they have to facilitate implications, support the effort and lead the action. In line with it, they described their role in STEM process from different perspectives as being the facilitator and supporter and leader.

4.2.3.1 Facilitator

The school principals are the facilitators of the schools by responding to the needs, by being the servant to handle the deficiencies, calling the experts when it is necessary to be involved in a project, etc. One of the school principals described his role in STEM education as "We help in getting technological devices. We have the smart boards provided by FATİH project and we aid our teachers to take the additional sources they need." (P9). Another school principal stated that they arranged trips to ASELSAN, TÜRKSAT, nuclear research center in Susuz, CERN. (P5). Another one sees his role in this process as "…making life easy for teachers when they are doing their job. (…)." He also stated that " I tell my teachers that we can handle what you want for educational practices. Yet, I need to see good intention." (P10). Other than this school principal, another one stated that "(…) How do we support the process as an administrator? We think about forming a robotics programming class." (P2).

Apart from those, one of the principals emphasized that "I constantly recommend our teachers to visit the labs related to STEM. We want them to spend time in the trip fields, and project fields about STEM in our city. Especially in the seminar terms, we invite the experts for briefing about STEM education." (P1).

Another school principal stated that

> I could describe myself as both leader and servant in the process. (…) We direct students according to the needs. Also, we try to meet the needs of our teachers. For example, HAVELSAN engineers give conferences to our students. They cooperate with ASELSAN and TÜRKSAT in the second semester for a training. There are studies done with CEOs coming from Science, Industry and Technology Ministry. (P8).

Being the facilitator in the environment requires responding to the needs, being the servant when it is necessary and searching and recommending for training opportunities for the development of both students and teachers are seen as the facilitator role of school principals in the STEM processes.

4.2.3.2 Supporter

Another role of the principal is supporting the teachers and students in STEM practices. They support both the processes and the communication environment by their actions. One of the school principals stated his support for students when they arrive at his door with an idea by saying

> When students have some problem or ideas, they come and tell about it. I support them with the subject. (…) They get the understanding about the subject and go. None of the projects is returned in this school if it has effort and thought in it and sounds plausible to me. (P9)

Another school principal stated the importance of group of teachers working together. "The group of teachers teaching mathematics could not be disconnected, group of physics teachers as well. When you talk about the group of mathematics teachers, they and the group of teachers in science should not be worlds apart. (…) Therefore, we need to bring them together from time to time." (P5). One of the school principals specified that "Principals do just the organization, be a model, and motivate." (P10) Another school principal emphasized the necessity of making students enthusiastic by

"telling them everything and sharing everything." (P6). All in all, it is indicated by most of the school principals that their job is to make teachers feel satisfied and to provide them with a good working place as stated by a principal as "My job is to make teachers pleased and peaceful, and make plans" (P3).

4.2.3.3. Motivator

Lastly, they are the motivators and guiders of the environment. Some see this role of being motivator as providing flexibility in the work environment while some consider it as being a guider in the way of improving school practices and providing opportunities for the self-development of teachers and students. One of the school principals stated his approach to being a school principal as "open door" policy, giving the freedom to talk about problems and ideas for teachers and students. (P9) Another identified his role as "orchestra chef", providing the harmony among teachers who also motivates teachers to do the things that are beneficial for students but have discrepancy with the regulations. Apart from those, one principal stated his leadership is doing the leadership together to have educational leadership and guidance in the school. Other than those, one school principal emphasized that he leads teachers to reach mission, vision and goal, and promote the successful teachers in this way (P7). In addition to those, one stated that "We provide them (the teachers) with appropriate (teaching) environment and try to keep their motivation high." (P6). Another emphasized that

> "I have a role in the school to give opportunity, direct and guide through the way and control at the same time. I have a leadership style to support teachers to improve themselves." (P11).

On the whole, we can say that all principals have a role defined for themselves to manage the STEM processes and all other activities in the school. The common thing in those schools is the freedom they gave to teachers and students to express their ideas and take an action after the permission is taken from the principals in projects and applications which is basically about motivating the teachers and students.

On the whole, in this chapter, the results of the qualitative analysis are presented under two head sections as qualitative description and content analysis. The main analysis included in the content analysis part tried to answer three research questions of the

study under nine themes. When the data gathered from high school principals are investigated with respect to their perception, experience and leadership in STEM education as a whole, the lack in knowledge, readiness and physical environment in schools attract attention.

CHAPTER 5

DISCUSSION and IMPLICATIONS

In this chapter, discussions and implications are presented regarding the results of the study. A brief summary of the results of each research question combined with the literature review and previous research is done together with discussion of the results and implications for theory, practice and methodology. The suggestions for the future studies are also indicated.

5.1. Discussion of the results

In this study, the purpose is to understand how high school principals perceive STEM education who work in prominent high schools of Ankara, what the experiences of school principals regarding STEM practices and how they define their roles in STEM practices at their schools. In this section, the results on research question are discussed in relation to the literature review. The discussion part covers the school principals' perception about STEM education, school principals' experience about STEM education, their role in STEM practices in the school.

5.1.1. School Principals' Perception about STEM Education

The results of this study showed that STEM education is not a concept that is understood by the high school principals who are working in prominent high schools of Ankara. The definitional issues of the STEM education are indicated in the literature as well, and the results of the study match with the previous studies. According to Brown et.al (2011), STEM education concept is not well understood by teachers and administrators they have studied with, which is consistent with the result of this study

as well. That is why some school principals indicated the reason why they do not have STEM education application as they do not have much of an idea about what it is. While some of the participant school principals consider it as the applications in the chemistry and biology labs, others see it as the implementations they do to turn theory into practice for students. Some of them admit that they could not do anything about what they do not have the knowledge. This is how the results of the study match with a study in the literature in which the readiness level of the teachers for the implementation of STEM education was measured through a quantitative analysis of their self-efficacy level and stage of concern level in STEM context. The results showed that only 5.53% of the teachers were well prepared for STEM education while the half of the teachers were not prepared (Geng, Jong & Chai, 2019). Another study supported these results by investigating the issue in mathematics teaching and finding that only a few teachers have accurate knowledge and perception about the integration of STEM education into mathematics (AlKhateeb, 2018).

Besides, parallel to the literature, definitional problems about the STEM education term are evident in this study as well. Participants of this study highlighted the definitional confusion of the term. The concern around definitional confusion is also the main concern in the literature where its lack of definitional agreement, even a framework for a definition, is the issue although the promotion of the concept constantly done by politicians, educators, profit and non-profit groups (Daugherty, 2013). On one hand, this educational approach created a stir. On the other hand, it does not have an epistemological foundation for both curriculum activities and for the training of teachers. Yet, one of the studies says that it is not a necessity to have a common STEM education definition but the schools need to form vision and goal statements about what their perception and approach to STEM education are for the implementation in their own school (Holmund, Lesseig & Slavit, 2018).

There are studies trying to form a framework that the STEM education could be based on. However, they do not cover the actual teaching and learning environment. Another criticism is that these studies are also based on different frameworks created by the researchers to inform the teachers or the educators about STEM education that they could later apply in their classrooms. A systematic review about this understanding of

TEM education framework stated five components regarding the studies investigated as "integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning and cooperative learning" (Thibaut et al., 2018). In addition, there are studies trying to understand the perception of teachers in different teaching areas about STEM education after giving training about the concept and how it could be applied in Turkey (Akran & Aşiroğlu, 2018; Çalışıcı & Sümen, 2018). Even though they had the training for what STEM education is and how it could be applied, some of teachers still think that STEM education is incompatible with the context because of different reasons. The studies in the literature mainly focus on the teacher perception where some of the studies add principals into their participants as educators along with the teachers (Çevik & Özgünay, 2018) showing the lack of knowledge in teachers and school principals and indicating the works to do to apply STEM education in Turkey. However, as indicated by one of the school principals in this study, it is not adequate to think about applying a concept without knowledge, and STEM education is the area about which most of the educators lack knowledge besides the conflict in the academia about what STEM is. In recent studies, the concept of "integrative STEM education" is revealed (Bartholomew, 2017; Havice, Havice, Waugaman &Walker, 2018), which creates a dilemma with the main notion behind "STEM education" which was supposed to be integrated educational practices in science, technology, engineering and mathematics. That shows the confusion about whether it is an interdisciplinary approach or not. If it is, why is there an indication of "integrative" showing up at the beginning of STEM education? That is why there is a need for a common definition of the STEM education to understand what it is for all if there is an intention to apply it as an educational approach globally and in Turkish context. Lack of consensus about the concept indicates a deep epistemological gap in relation to the concept of STEM education.

This moves us to another outcome of the study; STEM education as policy borrowing issue. STEM education became a global movement spread out from the United States of America, and there are many studies and attempts about this educational approach reflected in our country as well. The emergence of STEM education in Turkey has begun with the efforts of the academics who conducted their graduate education in the United States of America. They hold the advocacy of STEM education for different

reasons, such as adapting what they see in the United States of America to their country with the claim of the importance of STEM education for economic development, enthusiasm to affect the country with the knowledge they have, or build a career on the topic. Today, STEM education is used as an advertisement tool of in Turkish private schools to attract more students to their schools but in public schools, there is limited application field of STEM education. Yet, after the growth of the discussion about STEM education in Turkey, MoNE published a report about STEM education in Turkey, basically talking about what it is, how it could be applied in Turkey, and what steps should be taken to implement STEM education (MoNE, 2016). In this report, the necessity of action plan to train the teachers and future teachers and the change of the elementary and secondary school curriculum as integrating the STEM applications to each teaching area curriculum is indicated along with the necessity of establishment of STEM centers in universities merged to be part of MoNE STEM center in the future. Apart from those, the standardized tests and the number of the science and mathematics subjects in the educational system are pointed out as the obstacles against the implementation that require plans to get rid of (MoNE, 2016). Yet, the sudden appearance of STEM education without solid philosophy, definition and policy presents the lack of consideration in educational administration and planning side of the STEM education in global area as well as in Turkey. That is why STEM education is disconnected to the educational practices and there is a need for policy development if it is necessary to integrate STEM education which has not even a common definition bringing confusion about the concept. As indicated by the YEĞİTEK (Innovation and Educational Technologies Head Office) in the article "Handbook of STEM Education for Teachers" (2018), STEM education is not a new approach to learning and it is not a "have to do" for us. However, in the renewed curriculum, it is possible to integrate STEM education into teaching and learning environment in Turkey since it is about asking questions, doing research and inventions that do not require owning expensive infrastructure and programming knowledge. That is how MoNE sees STEM education (YEĞİTEK, 2018). While considering policy borrowing from other countries, it is essential to be prepared for the implementation wished to be done in the educational context regarding the borrowed policies. According to Nir, et. al. (2018) in the centralized educational

context, the issue of policy borrowing should be thought twice since the incongruence between policy to be adapted and the reality of the educational context may differ. Therefore, careful evaluation of borrowed policy should be done. That is why there is a need for full consideration of the policies to be borrowed and their advantages and disadvantages to be brought. When the United States of America and Turkey are compared in terms of STEM education needs, it could be seen that the context and the needs of the countries are different from each other and that leads to discrepancies in the implementation of STEM education in our country. As revealed in this study, the emphasis on university entrance exam and the appearance of concerns about the future are the primary obstacles towards the implementation of new policies and new educational approaches according to school principals. School principals mostly pointed out the problem in implementing the curriculum in the last two years of high school because of the university entrance exam. It is stated by most of the school principals that students as well as parents do not want teachers to implement the curriculum in the last two years of high school so that they can study for university entrance exam during the lesson hours. In that kind of environment, it is hard to implement curriculum based on asking questions, doing research and inventions and carrying out long term projects in science, engineering, technology and mathematics areas. That is just an example indicated by the participants of this study about why the needs and the context of the educational system are needed to be considered while thinking about borrowing policies from other countries.

School principals think that in the schools the teaching and learning processes flow with lecturing, which is the traditional way of teaching, and this is an obstacle towards the application of asking questions, doing research and inventions even if there are physical infrastructure and supplies. Parallel to the findings of this study and the literature, it can be argued that training for STEM teachers is an urgent need. However, the studies pointing out the need for teacher professional development in STEM education content also state the lack of epistemic framework to create this kind of training programs as well as the absence of teacher educators with interdisciplinary sense to teach STEM (Chai, 2019). While the emphasis is on the professional development need of teachers, this requirement is valid for school principals as well. They are the head where we can get informed about the curricular practices that

teachers do and new teaching methods used by teachers. In the studies working on the perceptions of the teachers, the need for professional development is indicated (AlKhateeb, 2018; Bartholomew, 2017; Chai, 2019; Havice, et.al., 2018). Instructional leadership is having the role in schools for the school effectiveness through the leading the instructional processes which could show different patterns in different schools because of the variables such as characteristics of school principals and the demographics of schools (Gokce, 2009; Gumus & Bellibas, 2016; Neumerski, 2012). Yet, there is a mediated effect of instructional leadership on student achievement (Blase and Blase, 1999). Therefore, through instructional leadership, school principals could advise to the teachers about the implementation to be more effective. That is why they are responsible for learning new concepts that they wish their teachers to learn. For those who are responsible for informing the teachers, it is necessary to catch up with what is new, especially if it is published by the MONE. However, there is a lack of knowledge among school principals about STEM education which is an obstacle to lead teachers and support the implementations in the instructional processes regarding STEM practices as the results of this study is revealed. As the teachers need professional development as indicated in the literature in many studies to implement STEM education, school principals need training, too.

While YEĞİTEK (2018) sees STEM education as an approach which does not need expensive infrastructure and programming knowledge, school principals in this study emphasized their lack of infrastructure and physical facilities to implement this educational practice as 3D printers, and computers with high performance capacities. One of the participant even gave the example from high schools which established STEM laboratory with the support of TOFAŞ. Some of the school principals and teachers make sacrifices for the usage of those kinds of infrastructure by taking their students to the facilities with those physical supplies. Yet, some of them pointed out their need for those kinds of supplies but not having the financial support to provide physical facilities. Another participant school principal in the study indicated that the school principal needs to be entrepreneur to provide all the opportunities to the school by finding donators, financial and academic support. That is how the schools could be improved and have opportunity in their schools as private schools or public schools with the donator companies. That is why there is incoherence among the schools for

reaching the same infrastructure when it is seen that some of them do not have even FATİH project infrastructure providing tablets, internet and smart boards. Therefore, there is a need for support and planning for schools to have physical infrastructure in Turkey as well to supply social justice between public and private schools where the public schools seem disadvantaged about infrastructure issue. The lack of infrastructure cause miss in the instructional opportunities is what the school principals are pointed out in this study which creates the incongruence between students regarding human capital comprising social and cultural capitals. Thus, the opportunities that STEM offers in higher education and in work place are not provided for every individual in the country but for the ones who have taken the advantage of STEM education in their compulsory level of education (Kondakci & Kulakoglu, 2018). In the literature, the need for closing the gaps among the schools is also indicated since the infrastructural advantages turn into outperform in students' performance and an increase of the number of ICT (information and communication technologies) aided courses. (Gouda, Chandra Das, Goli & Maikho Apollo Pou, 2013; Lu, Tsai & Wu, 2015). Therefore, even though YEĞİTEK (2018) pointed out that STEM education do not require expensive infrastructures to implement in the schools, the school principals emphasized the need of supplying necessary tools used in STEM education which is also necessary to catch the educational opportunities offered in private schools or donated schools to close the gap between the schools. Yet, it is not enough to provide only physical infrastructure. There is also need for human infrastructure that is teachers and principals with the knowledge of integrative education as it was indicated previously in this section since there is not enough knowledge about STEM education, leading to a mismatch between perception of school principals and the reality of STEM education.

In this study, the flaws of STEM education are also investigated and the opinions of school principals are taken. Some of the school principals pointed out the deficiencies of STEM education regarding the preparation of students to the future having capability in scientific areas as well as social context. That is why there is a controversy in the literature about this issue comparing STEM education with STEAM education, and some academics defend the superiority of STEAM education. Land (2013) stated that while STEM education provides individuals with high-tech skills, the STEAM

education moves it further by integrating arts and attaining ability using analytical thinking, and solving simultaneous complex problems with creative thinking skills. Apart from its contributions to the creative and analytical thinking of STEAM for individuals, there are moral and responsibility issues that STEM education lacks and STEAM education assumes to fill. All of the participant school principals in this study agreed on that the arts and social sciences are important parts of education for students to be in the society with their attained knowledge of science and technology, as well as their intellectual development. As stated by one of the school principals, when all those technology developments are considered, the part of humans making them different from robots and artificial intelligences is their human side with all the caring, thought, ethics and moral values as well as artistic and aesthetic concerns. Therefore, there are different activities they make in their schools comprising theatre, drawing, music, poetry, literature, social responsibility projects and conferences. Yet, those are not integrated to the STEM education but thought as separate fields to be learnt dis-jointly from science, engineering, technology and mathematics. Also, some of them think that they cannot be merged for the purpose of integrative education since the fields are so separate from one another. However, Elon Musk is the counter example of this initiative merging scientific developments with the human side of individuals caring about the world they live, which makes humans different from the robots. When he gets the patents of the engines developed for Tesla cars working with electricity, he opened those patents for public usage (Musk, 2014). He put the sustainability of our world to the front of global competition among automotive giants through reducing the carbon emission. That is why he expected to be used these patents to be used by other automotive companies for renewable transportation sources.

This kind of consideration is important in scientific and technological advancements because this world does not just belong to human kind but there are many species we need to think about while taking decisions concerning our world. The importance of the responsibility, ethics, values in STEM education and STEM areas converting it into STEAM one is indicated by Lanchman (2017) as you can make millions in technology area and impact many people yet the algorithm you write needs to improve individuals rather than just impact them. Therefore, STEAM education is needed over

STEM education in order to raise individuals with important values and ethical concerns for the world they live in.

5.1.2. School Principals' Experiences about STEM Education

Regarding the STEM education experiences of school principals in their schools, themes emerged in this study include the openness of students to learning arising from their quality indicated by principals, the training need of teachers for this kind of integrative education as emerged in previous question and how the TÜBİTAK projects as well as innovative implementations are seen as STEM experiences in the schools. The schools in the sample of this study are prominent schools having qualified and distinguished students who have taken high scores in standardized high school entrance exam. Therefore, the expectation of success from those students in university entrance exam is high. School principals, in this study, described the profile of the students as motivated and enthusiastic to learn and qualified with the knowledge, moving them ahead of their peers. Their enthusiasm towards science and mathematics and choosing career path in medicine and engineering are the highlights of school principals. Also, the administration and the teachers of the schools have high expectations from the students in the university entrance exam. This is supported by one of the studies conducted by Akgündüz (2016) stating that the career choice of top thousands students in university entrance exam in Turkey showed the interest towards medicine increased over time while the attention given to STEM areas decreased for those students between the years 2000 and 2014. Moreover, the choice of faculties of education and basic (hard) sciences remained relatively low for those students. According to Wang (2013), the choice of a career in STEM pathway depends on different individual, psychological, contextual, and social dispositions. Yet, the results of this study showed that school principals prefer their students to get into STEM areas as a career choice for their undergraduate degree because of the success of students in the mathematics and science areas. This could be seen reasonable because of the success but this approach does not give importance to the field of interest of students. The reason of this approach could be because of the measurement of success for those schools as the number of students getting into engineering and medicine departments as a career choice as indicated by the school principals.

The understanding of participant school principals about STEM education or STEM concept is about the university level education in science, mathematics, technology and especially in engineering areas as well as medicine since the integration of those disciplines as an integrated whole to form STEM education seems complicated and impracticable in high schools. Therefore, their perception of STEM education is restricted with four separate disciplines most of the time except some project based activity opportunities they offer for not all but some of the students. Those students are mostly interested in doing inquiry and they are supported by their teachers and school principal for the ideas they have for project based competitions done regularly by TÜBİTAK (The Scientific and Technological Research Council of Turkey). The participant school principals indicated their support and enthusiasm towards new project ideas coming from both students and teachers because those projects could be successful in the competition and get awards raising the reputation of the school. The project competitions done by TÜBİTAK in technology design and engineering; social sciences and science and mathematics areas are given importance by the high schools as the proof of prominence and the commendation of the school. According to TÜBİTAK, those projects are to improve learning skills, to learn carrying out research and using the necessary tool to explore exciting phenomenon and to raise individuals having a career focus and approaching every problem like a project with self-esteem and capability. Individulas will be prepared for the life and the university level (Bilim İnsanı Destek Programları Başkanlığı, 2019). Unfortunately, those project based learning and teaching competitions are not applicable for every student in high schools. The students to participate in these project based learning and teaching competitions are either selected for this process by school principal and teachers or they come up with an idea to their teachers that could be presented in these competitions as the results of the study indicated. It is true that every student could not be interested in STEM areas and could have interest in social sciences. TÜBİTAK project competitions are not in just STEM areas but in different areas comprising social sciences as well. Therefore, it is not a complete STEM application competition but it is an opportunity for participant students for project based learning in every area. Yet, school principals perceive those competitions just as STEM application. Since there is no concrete STEM education perception in their minds creating confusion where to place this

educational approach, preparing projects for TÜBİTAK high school competitions seems to meet the term.

According to the results of this study, in high schools, there is no concrete application regarding STEM education and this is because of the lack of understanding directing school principals to perceive it as doing projects in TÜBİTAK competitions and lack of knowledge about how to implement STEM education. The schools forming the sample of this study are prominent schools regarding their educational quality and student profile interested mostly in science and mathematics areas or at least directed to those areas by the social environment because of the way they use knowledge they have in expected way in those areas. It should not be forgotten that education is about whole person development having knowledge to use in social life as well as in academic life with wisdom. As one of the participant school principals pointed out that those students have a promising future with the knowledge they have in STEM areas but they lack social skills and they need to be improved in those areas as this school principal tries to do in his school (P11). Therefore, giving importance to the growth of students as individuals with all necessary social and scientific skills should be the priority of the educational system, since the values as ethic, responsibility and caring should go hand in hand with scientific knowledge to have conscious generations using the wisdom for the good of humanity and the world, not for only himself/herself.

To sum up, regarding STEM education experiences in prominent high schools of Ankara, there are ready students for those processes as indicated by school principals with their capabilities in using knowledge in the science, technology, engineering and mathematics areas. Yet, there are no concrete STEM education applications in those schools. Even the school establishing the "garage" has also concerns about how they could implement such practices in their school because of the deficiencies between the "garage" concept and the educational context. Also, TÜBİTAK project competitions are not just based on STEM related areas but also based on social scientific areas which direct students to learn by preparing projects. It is important to remember that education is for the full preparation of students to the life-long skills as well as the improvement of academic knowledge which will be used together for the survival in the social life. Whole individual development is necessary for all students to be useful

for their society they live in and for the moral issues they need to develop for the usage of the knowledge they have to impact the same society.

5.1.3. School Principals' Role in STEM Education

In the recent study, the document analysis on the vision and mission statements of the schools shows that these statements are fuzzy and very general. In the semi structured interviews, there were questions about vision and mission statements and their relation with STEM education but the school principals pointed out that those statements are identified in the direction and framework defined by MoNE and they generally resemble each other and not mention STEM education practices or technological enhancement goals of the schools. However, according to the study done by Goldring and Pasternack (2006), the strategies applied for the increase of school effectiveness through the change processes by school principals, rather than traditional instruments, the preparation of goals and school mission is the most influential instrumental factor in relation to school effectiveness. Also, although school principals could have positive attitudes towards technology usage in the classrooms and courses, they need to show their positive attitudes more concretely by integrating technological and innovative aims into vision of the school to provide necessary involvement and more effective learning environment (Cakir, 2012). Therefore, it can be claimed that the mission and vision statements of the school have an important place in the schools to go beyond the borders and realize the technological and innovative changes in the schools.

STEM education requires change in the teaching and learning environment of the schools and this needs preparation starting with the written statements of the schools to make a realization of permanent change. However, in Turkey, the changes and reforms are done in each school in the same way by MoNE (Kondakci, Orucu, Oguz & Beycioglu, 2019) without the consideration of school type, student profile or the socioeconomic status around the schools' location is done. Therefore, the educational change process requires school principals to take on responsibility for identification of the scale of the educational change in the school as well as the vision and mission statements. However, regarding STEM education, there is not such kind of an action in the schools to be taken to go to the next step as the results of the recent study showed. Participant school principals did not define their role in the school as forming mission

and vision statements of the school or at least leading this movement. Yet, in STEM education process, how a school principal locates his/her position to lead the school environment and the implementation done is important.

In this study, they identify themselves in the position of motivator, supporter and facilitator in general. Most of the principals indicated the importance of being a leader by providing motivation and flexibility, applying an "open door" system for teachers and students to tell their problems and ideas, playing the role of "orchestra chef" to sustain harmony, being the person in charge of all processes in addition to providing participatory decision making processes for teachers. They follow those processes not just for their experiences perceived as STEM practices but also for all educational processes. According to the study done by Akbaba-Altun (2004), while school principals provide facilitation, staff development and communication in information technologies (IT) processes, principals need to add instructional and technological leadership, supervision, planning, coordination, public relation, empowerment, ethics and security into those features. Those mentioned properties match with the ones indicated in the recent study by the high school principals as being facilitator, motivator and supporter.

School principals are the leaders and the head of the schools who meet the needs by handling the deficiencies when it is asked by teachers or it is necessary. According to results of this study, school principals mostly perceive their role in STEM education as facilitators, supporters and motivators. This facilitation job includes wide range of tasks including preparation of the school for each semester physically, contacting the people with knowledge to brief students and teachers for subjects that seem necessary for the improvement all of which is for the contribution to the quality of the teaching and learning environment. The participant school principals indicated their facilitator role as being servant, providing informational support by arranging meetings with experts, supplying physical needs as 3D printers, computers, tablets. Apart from a few school principals, most of them mentioned their overall role in the school as a facilitator by not talking about role in STEM practices. As there is no knowledge about this educational approach among the principals, they stated their lack of practices and role in STEM education. Yet, the facilitator role of the school principals is important

aspect of their job since supplying the needs and requirements in the teaching and learning environment asked by teachers and students could make the process of learning more efficient in all learning processes including STEM practices.

In addition to the facilitation role of school principals, they define another role they have in the process as being a supporter. In schools, it is important to provide an efficient teaching and learning environment. Therefore, in order to implement STEM education practices in high schools, as indicated by the participant school principals, the role as a supporter is important to encourage teachers first to professionally develop themselves, then for the students to take a step to be part of the STEM practices. Also, school principals take the role of gathering teachers in the same teaching area or in different teaching areas to collaborate and appreciate the work they do together to support them to collaborate more. The participant school principals emphasized the importance of the support of new ideas and the entrepreneurship of both teachers and students in the way of trying new things and taking risks as well. According to Bredeson (2000), for the teacher development, principals have three main roles as being supporter, communicator and manager to create a learning environment for teachers and the improvement of the school. The support could be professional, psychological and emotional support with which the teachers could take risks to try new practices and reveal their creativity in the process of teaching. Thus, for creating a teaching and learning environment that has challenging project to implement in the school, the school principals should take the lead and support the action by considering the benefits of the initiated implementations for teachers and students (Ackley, 2009). In this sense the perception of participant school principals regarding their role in STEM practices in this study match with the literature. The support coming from the school principals encourage teachers and students to be entrepreneur and give them flexibility and motivation to try new things in the teaching and learning processes. Their role as supporter is important because of those reasons.

Last but not least, the participant school principals pointed out the importance of being a motivator for teachers in the implementation of different practices which is part of being a leader. Being a good motivator as a leader implies variety of actions such as providing flexibility in the working environment, sustaining the motivation through

the process of teaching and learning, participating staff to the decision making processes for what will be done, taking risks for implementing what is best for students and guiding all the processes as the head of the school. As stated by Wahlstrom and Louis (2008), the principal leadership impact on student achievement is inevitable and the study they have done revealed the importance of teacher-principal and teacher-teacher communication through the shared leadership for decision making processes in the school about the instructional purposes. Therefore, the mentioned characteristics of providing motivation that the participant school principals emphasized are important because of creating a teaching and learning environment including shared decision making, flexibility and sustaining motivation. The emphasis on providing flexible environment and supporting the new ideas is necessary for the creativity of teachers to implement those ideas which is important in STEM practices as well since it requires creativity and flexibility in the implementation process.

To sum up, the role of school principals not just in STEM education but in all teaching and learning practices are being a motivator, supporter and facilitator. Providing the necessary materials and meeting the requirements, supporting the new ideas and allowing the teachers and students to involve in in challenging and risky projects are the roles of school principals that are needed in the process of new implementations revealed as STEM education. In addition to those, being the leader in this process who motivates, takes risks, takes decisions with teachers, provides healthy communication environment is another role for school principals to lead the educational processes including STEM practices for the favor of school effectiveness.

5.2. Implications for Turkish Educational System

In the literature, there are many studies about STEM education investigating it from different perspectives as curriculum, teacher development, student readiness and effectiveness but studies approaching to this educational practice from the perspective of school principals were very limited in number and content. When the importance of school principals for the school effectiveness and the student achievement is considered, as the head of the instructional practices and the most knowledgeable person in the eyes of teachers and students, their perception regarding STEM education gains importance for the implementation and the sustainability of those kinds of

practices. Therefore, this study aims to understand the perception of high school principals about STEM education who are working in the prominent schools of Ankara province and the country according to the student achievement level measured by standardized tests and the placement of those students to the high ranking universities of the country.

This study examined how the head of the school principals perceived STEM education, not trying to measure the effectiveness of the STEM education. These educational practices could have promising effects on student learning and the preparation of students with 21st century skills for the life as it was claimed in the literature and policy reports. Yet, there is not enough level of readiness and knowledge regarding the concept. In an environment without enough knowledge, how one can expect to have implication that has an impact on student learning. As participant school principals of this study indicated, when the implementation is tried to be done with sudden decision making without any proper preparation of physical infrastructure and human resources, there can only be a new course named as STEM practices taught in regular lecturing method, not in an interdisciplinary perception.

First issue regarding STEM education is the mismatch of the Turkish educational context with the main purposes of revealing the STEM education. The sudden popularity of the STEM education was because of its claim on the country's economic enhancement placing them to the higher ranking in the global market. The willingness of the United States of America regarding holding the number one position in the Gross Domestic Product (GDP) among all countries is the reason why STEM education was revealed. The competition in the economic area and the concern regarding the rapid growth of the countries of China and India made the United States of America to take precautions by revealing the plan that gives importance to the STEM areas with the initiative announced by Obama as Educate to Innovate (Office of Press Secretary, 2009). This initiative takes the lead in the educational area in the United States of America by affecting the educational practices, policies and academy. In relation to the contribution of STEM education to the economy, the United States of America have the motive to initiate this approach to raise STEM area workers coming from the STEM pipeline, who were born in the United States of America (Land, 2013). Because

of the return of foreign individuals to their home country after their education is over in the United States of America caused the loss of the educated and qualified individuals, the country launched this STEM movement. When the motive to initiate this movement is for the United States of America, it can be said that they act according to their educational and policy needs for the raise of next generations for the country's favor. Yet, the motive is not valid for Turkey since our concern is about non-return of our educated individuals from the foreign countries after they complete their education or get experience for a couple of years if they have gone to foreign countries. Also, keeping the individuals in the country by providing the quality education or job opportunities after the graduation is another concern for Turkey in STEM areas which is related to preventing brain drain of those individuals.

According to the statistics published by Higher Education Council (2017; 2018; 2019), the number of graduates of the engineering programs has been higher than 50,000 in the last three years and the number of graduates of natural and applied sciences is around 15,000. Those statistics indicate that there is no need for STEM education in our country when the comparison with the whole population and the graduates of those programs in each year is done. The employment issue of those engineering and natural and applied sciences graduates is revealed with the increasing number of graduates in Turkey. Therefore, directing more and more students to the STEM areas to have a career is not a valid purpose for Turkey although it is proper for the United States of America. Yet, this result of this study pointed out that the school principals in the prominent schools of Ankara stated the quality of the students by indicating their achievement in the science and mathematics areas and the guidance of those students to the STEM areas. In our country, there is a need to consider an educational approach for individuals to be directed to their interested areas, not just to STEM areas, because the point should not be to have individuals in STEM areas because of their success in science and mathematics but to choose their path for the future where they can both contribute to the social and academic life and be happy. Therefore, for STEM education practices to implement in our schools, first there is a need for a concrete educational purpose in favor of students and the country. This is where the policy issue comes to the surface. Policy transferring or policy borrowing is risky for countries because of non-matching contexts of the countries as discussed earlier. Therefore,

instead of borrowing the policies, the policy making that responds to the needs of the country is a more sensible option as in the case of STEM education. Unlike many other countries, Turkey has enough number of graduates in STEM fields. Rather, there are graduates of those areas more than needed. Therefore, rather than directing qualified students to STEM areas, taking policy actions regarding the needs of the country about STEM-related graduates and the students is the priority.

As the United States of America launched this STEM movement, it spread out to the world and the impact of STEM education became contagious even though there is not enough knowledge and perception about what it is and how it could be implemented. Therefore, this caused some attempts to apply STEM practices without proper knowledge and preparation, showing lack of readiness as the results revealed in this study. Therefore, *second problem* regarding the implementation is the lack of infrastructure that the STEM practices need and the social justice issue which these infrastructural problems brings to light. The infrastructure has two components as physical and human infrastructure. Even though the tablets, smart boards and computers are provided to many schools in Turkey after the launch of FATİH project, there are still schools without this opportunity. In addition to this, as the school principals perceived the STEM education, it requires more than just smart boards and computers, including 3D printers, programming applications, high quality computers and the materials to handle the structural needs of the projects. Therefore, there is firstly a need to equate the opportunities in the schools for all students to reach the same facilities, then to improve those qualities owned by the schools. Physical facilities are important parts of the schools making the teaching and learning environments more efficient and keeping classrooms matching with the age we live.

It is not enough to have those physical facilities in the classrooms if there is no use of those facilities in the teaching and learning process. Therefore, *another issue* regarding the implementation of STEM education is the teaching methods and teachers who will supposed to be use those methods. The school principals mentioned that the flow of the courses is done through the traditional way of teaching rather than using the facilities the schools have. For that purpose, the teachers should be supported to try new methods in the classroom. STEM education requires trying new paths in the

classrooms rather than traditional method. About this issue, some of the participant school principals admit that the schools are not ready for this kind of implementation because of the lack of readiness of teachers and the participant school principals' own lack of knowledge. Therefore, the emphasis of the teachers' professional development need for STEM education was done in different research (AlKhateeb, 2018; Bartholomew, 2017; Chai, 2019; Havice, et.al., 2018). This present research contributes to those studies regarding the lack of readiness of school principals as the STEM education perception showed the lack of knowledge. In order to provide an environment for STEM education practices, the school principals should take the lead to motivate the teachers and support the action done.

They could not undertake a role in STEM education practices because of the lack of knowledge and infrastructure in addition to the incompatibility of STEM education with the system flow in the schools which is the *fourth issue* creating an obstacle regarding the implementation of STEM education in Turkish educational context. While school principals lack knowledge and perception regarding STEM education as the head of the school, who are also the instructional leaders, it is not valid to expect teachers to initiate integrative educational practices on their own without the support and knowledge of the school principals. Therefore, creating an organizational culture for the STEM education is required (Kondakci & Kulakoglu, 2018) to prepare schools in terms of physical and human infrastructure to internalize the concept for the proper and sustainable implementation. To create this kind of an organizational culture, there is firstly a need for changing organizational culture with regards to the norms, values, philosophy and vision (Lunenburg & Ornstein, 2004). When the dependence of all schools on MoNE regarding their vision and mission statements, before any action expected from the schools, ministry should take the lead about STEM education practices to be integrated into school context by guiding schools for the vision and mission statements to be formed. If the change is done from top to down, then the openness of the schools to changing organizational culture could increase. Yet, when all those flaws and obstacles towards the implementation of STEM education as the lack of mission and vision for STEM-related practices, the lack of human and physical infrastructure, policy borrowing without proper consideration about the context, the incompatibility of STEM-related implementation with the curriculum and practices

and the lack of perception and knowledge for STEM education are considered the conclusion arrived is about not implementing STEM education in our schools. The reality of the schools regarding the attempts to integrate STEM education into schools does not match what is written on the paper about how it could be implemented. Therefore, there is more time needed to implement STEM practices than the traditional teaching and learning practices and more effort needed to prepare STEM-related activities integrated into curriculum which is unrelated to STEM practices (Kanadli, 2019).

Apart from all those flaws, *the last issue* is that the curriculum and the teaching and learning environment provided in Turkey do not meet the needs of interdisciplinary educational approach since there is no knowledge of teachers and pre-service teachers about integrated practices. In order to expect teachers to integrate more than two disciplines into their courses, there is a need to raise those pre-service teachers in the university regarding the integrative education. Yet, there is a concern related to the teacher educators since there are not enough teacher educators in the universities that have an interdisciplinary sense to teach STEM (Chai, 2019). That is why educational reforms and changes require time and effort comprising all stake holders of the educational system including MoNE, universities, academy, schools and policy makers. In order to expect schools to integrate STEM areas, firstly those parts of the educational system should collaborate for improvement in school effectiveness. Reforms could take time, but instead of short term solutions, there is a need to chase long term opportunities by taking the time to apply reform actions slowly, not immediately. Therefore, insisting on the integration of STEM education into our educational system is not the right thing to do in the present time because of the lack of perception, lack of knowledge and lack of infrastructure forming a barrier towards the improvement of the school effectiveness according to the results of this study which has taken the perception of school principals regarding STEM education.

5.3 Limitations of the study

First of all, the study was conducted with the participant school principals working in science high schools as well as the project high schools in Ankara province which are thought to be the prominent school of the area. Because the specific type of the high

schools is investigated this research could only be valid for those schools. Although there is no concern of generalizability in qualitative research, deeply understanding the perception of more school principals in different provinces or in different school types will enrich the literature by looking at STEM education from the perspective of school management.

Secondly, there could be a researcher bias generating from the nature of qualitative research. This could be unconscious expression revealed during interview or the impressions made in some answers. Yet, as the researcher and interviewer, I tried to stay objective while asking questions. Also, in order to prevent the researcher bias in the data analysis, the interrater reliability is sustained by taking coding of some interviews from four of my colleagues. Even though the precautions are taken towards the researcher bias, there could be some unconscious actions as it was mentioned by Fraenkel, Wallen, Huyn (2015). Also, there could be an interviewee threat in qualitative research arising from the communication skills. As I experienced during the interviews, school principals have an intention talk about all the practices they made in their schools apart from what is asked. Thus, as the interviewer, I needed to be careful and to control the interview session to keep school principals in the subject of STEM education.

Thirdly, in this study, STEM education concept is investigated only from the management perspective by interviewing with the school principals. Yet, there is a need for deeper understanding of the implementation, teacher and student perception about STEM education since the teaching and learning practices are basically the base of school experiences.

5.4 Recommendations for Future Research

As this study is one of the pioneers regarding to learn about high school principals' perception of STEM education, the data collected from the school principals working in the prominent high schools of Ankara province. For further studies, it could be suggested to investigate the issue deeper in other provinces in Turkey so that the results of this study could be expanded for the other high school types or educational settings.

Secondly, approaching the STEM education in Turkish educational context from organizational culture perspective could give more insight about the compatibility of STEM education in the schools. Since there is an organizational culture issue apart from discussed structural and human source of the STEM education, it is needed to be investigated.

Thirdly, the recommendation for policy makers and practitioners is to direct the effort given to the integration of STEM education into the improvement of science and mathematics courses in schools. It could be more beneficial to take action about the teaching and learning environment provided for mathematics and science courses to improve the knowledge of students in those areas since the results of standardized and centralized university entrance exam done every year by ÖSYM (Assessment, Selection and Placement Center) showed that the students mean level of basic mathematics was 6.08 out of 40 questions and science was 2.70 out of 40 questions this year (2019). According to the results of the standardized university exam, it is important to consider solutions for the improvement of the students' level of basic mathematics and science skills.

Lastly, as YEĞİTEK (2018) pointed out that STEM education is not a new concept but it is a holistic approach of all the methods that are implemented in our schools and the compatibility of renewed curriculum with the STEM education practices, this issue could be studied in future research.

5.5. Conclusions

The results of this study indicated the lack of readiness, knowledge and infrastructure as obstacles towards applying STEM education in schools according to the data collected from school principals. In addition to those, the incompatibility of the STEM education with Turkish educational context and the lack of teacher educators to teach how to implement courses with interdisciplinary sense are other conclusions that this study is revealed.

Firstly, the concept of STEM education is not understood and there is lack of knowledge about what it is and how it could be integrated into the implementations in

the school practices. Asking teachers to implement an approach that the school principals lack of knowledge is not fair when it comes to the application. As the instructional leaders, school principals need to be the ones that have the knowledge about the STEM education in the first place to lead teachers in the way of implementation. Yet, they admitted the lack of knowledge of their own as well as the teachers as a drawback for implementing STEM education.

Secondly, the physical infrastructure of the schools is not compatible with the STEM education requirements as 3D printers, programing applications, high quality computers. While some of the schools own the foundational technological devices for the integration of technology in the classrooms, it is not enough for STEM education and some of the schools do not even have the opportunity of those foundational infrastructure. Therefore, the first need in the schools is to equate the infrastructural opportunities and then move further by supplying necessary programs, materials and software for STEM practices.

Thirdly, even though those physical infrastructures are gained to the schools, there will be need for the human resources to use those facilities. Therefore, the issue is not just physical but also human infrastructure to be improved for the implementation of STEM practices. For this reason, in service trainings could be applied to the school principals and teachers in order to raise their awareness about the concept and how it could be implemented. Yet, the preservice teachers also need to be trained for integrative teaching practices but there is lack of teacher educators teaching in integrative perspective. Therefore, integrative approaches as STEM education requires the teachers to be trained in that sense. Because even though the curriculum could be proper for STEM education practices as indicated by YEĞİTEK (2018), the teaching methods used and the lack of understanding towards integrative educational practices are another setback towards STEM education as indicated by school principals. The attempt to apply STEM educational course in the schools will turn into a course not different than regular mathematics or science class with traditional teaching and learning practices as mentioned by one of the school principals. Thus, teachers and school principals should be educated in that sense if it is vital to implement STEM education in the schools.

Last but not least, educational policies of each country should be unique to their own country since each of them have their cultural, social, historical background affecting the way of raising the future generations for their societal needs. Therefore, countries should take how they fit the borrowed policy into their own context into account while they are borrowing educational policies. Yet, STEM education is a policy that fits into the context of the United States of America but not Turkey because of the reasons mentioned earlier such as the human capital needs of these two countries. In addition to this, STEM education is not compatible with the culture and context of the Turkish educational system since the traditional way of teaching and learning environment and the educational processes in the schools which are forming the culture of the schools do not match with the STEM education needs. For that reason, if it is wished to implement STEM education in the schools, the conversion of the educational culture is needed for the schools based on traditional curricular practices, and the preparation of students to standardized university entrance exam in high schools.

To conclude, the managerial side of the schools have not enough knowledge and valid understanding of the concept STEM education regarding the results of their perception, experience and roles about STEM education. This result is compatible with the previous studies done with teachers about the issue since the suggestions in Turkey and other countries includes teacher training and infrastructural enhancements. At this point, the lack of knowledge, readiness and infrastructure of school principals showed that the implementation of STEM education is hard for Turkish context. Directing the effort given to STEM education implementation attempts to the improvement of school effectiveness through the development of current educational practices could be more valuable for the educational system of the country since every educational context is unique and the requirements to enhance the learning are different for each country.

REFERENCES

Acemoglu, D., Johnson, S., & Robinson J. A. (2005). "Institutions as a fundamental cause of long-run growth." In *Handbook of Economic Growth*, edited by Philippe Aghion and Steven N. Durlauf, 385–472. Amsterdam: North Holland.

Ackley, C. R. (2009). *Leadership in green schools: School principals as agents of social responsibility* (Doctoral Dissertation). Retrieved from https://etda.libraries.psu.edu/files/final_submissions/1107

Afshari, M., Bakar, K. A., Luan, W. S., Samah, B. A., & Fooi, F. S. (2008). School leadership and information communication technology. *Turkish Online Journal of Educational Technology-TOJET, 7*(4), 82-91

Akbaba-Altun, S. (2004). Information technology classrooms and elementary school principals' roles: Turkish experience. *Education and Information Technologies, 9*(3), 255-270.

Akgunduz, D. (2016). A research about the placement of the top thousand students in STEM fields in Turkey between 2000 and 2014. *Eurasia Journal of Mathematics, Science & Technology Education, 12*(5), 1365-1377.

Akran, S. K., & Asiroglu, S. (2018). Perceptions of teachers towards the STEM education and the constructivist education approach: Is the constructivist education approach preparatory to the STEM education?. *Universal Journal of Educational Research, 6*(10), 2175-2186.

AlKhateeb, M. A. (2018). The degree practices for mathematics teachers STEM education. *Cypriot Journal of Educational Science, 13*(3), 360-371.

Anderson, R. E., & Dexter, S. (2005). School technology leadership: An empirical investigation of prevalence and effect. *Educational Administration Quarterly, 41*(1), 49-82.

Apple. (2017, December 28). A Message to Our Customers. Retrieved February 01, 2018, from https://www.apple.com/iphone-battery-and-performance/

Asik, G., Doganca Kucuk, Z., Helvaci B., & Corlu, S. M. (2017). Integrated teaching project: A sustainable approach to teacher education. *Turkish Journal of Education, 6*(4), 200-2015. doi: 10.19128/turje.332731

Atkinson, R. D. (2012). Why the current education reform strategy won't work. *Issues in Science and Technology, 28*(3), 29-36.

Augustine N. (2008). Rising above the gathering storm: energizing and employing America for a brighter economic future. National Academy Press, Washington, DC

Baird, J., Johnson, S., Hopfenbeck, T. N., Isaacs, T., Sprague, T., Stobart, G., & Yu, G. (2016). On the supranational spell of PISA in policy. *Educational Research, 58*(2), 121-138. doi:10.1080/00131881.2016.1165410

Ballentine, J.H., Hammack, F. M.(2015). Sociology of education: A unique perspective on schools. In Ballentine, J. H., Spade, J. (Eds.). *Schools and society: A sociological approach to education*. (5th ed., pp.1-26). Thousand Oaks, CA: Sage.

Baran, E., Bilici, S. C., Mesutoglu, C., & Ocak, C. (2016). Moving STEM beyond Schools: Students' perceptions about an out-of-school STEM education Program. *International Journal Of Education In Mathematics, Science And Technology*, 4(1), 9-19.

Bartholomew, S. R. (2017). Using Pokéman GO to teach integrative STEM. *Technology and Engineering Teacher, 76*(5), 24–27. Retrieved May 17, 2019 from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1130730&site=ehost-live

Becker, G.S. (1964): Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education, New York.

Becker, G.S.(2018).Human Capital. Retrieved June 25, 2018 from https://www.econlib.org/library/Enc/HumanCapital.html?highlight=%5B%22human%22,%22capital%22,%22becker%22%5D

Beckett, K. (2018). John Dewey's conception of education: Finding common ground with R. S. Peters and Paulo Freire. *Educational Philosophy & Theory*, 50(4), 380-389. doi:10.1080/00131857.2017.1365705

Beede, D. N., Julian, T. A., Langdon, D., McKittrick, G., Khan, B., & Doms, M. E. (2011). *Women in STEM: A gender gap to innovation.* U.S. Department of Commerce, Economics and Statistics Administration

Bell, D. (2016). The reality of STEM education, design and technology teachers' perceptions: a phenomenographic study. *International Journal Of Technology & Design Education*, 26(1), 61-79. doi:10.1007/s10798-015-9300-9

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House*, *83*(2), 39-43.

Berry, T.(2014, November 5). I'm a female engineer, and I love science. Stop calling me a geek. *Washington Post.* Retrieved January 24, 2019 from https://www.washingtonpost.com/posteverything/wp/2014/11/05/im-a-woman-engineer-and-i-love-science-stop-calling-me-a-geek/?utm_term=.e069e1a89fad

Bilim İnsanı Destek Programları Başkanlığı (2019). *Lise öğrencileri araştirma projeleri yarişmasi proje rehberi*. [online] Retrieved June 28, 2019 from http://www.tubitak.gov.tr/sites/default/files/2750/lise_rehberi_2019_.pdf

Blase, J., & Blase, J. (1999). Principals' Instructional Leadership and Teacher Development. *Educational Administration Quarterly, 35*, 349-378. doi:10.1177/0013161X99353003

Bredeson, P. V. (2000). The school principal's role in teacher professional development. *Journal of In-Service Education*, *26*(2), 385-401.

Breiner, J. M., Harkness, S. S., Johnson, C. C., & Koehler, C. M. (2012). What Is STEM? A Discussion about Conceptions of STEM in Education and Partnerships. *School Science and Mathematics*, *112*(1), 3–11.

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: current perceptions. *Technology and Engineering Teacher*, *70*(6), 5.

Brown, B., & Jacobsen, M. (2016). Principals' Technology Leadership. *Journal of School Leadership*, *26*(5), 811-836.

Burner, T. (2018). Why is educational change so difficult and how can we make it more effective?.

Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. NSTA press.

Cakir, R. (2012). Technology integration and technology leadership in schools as learning organizations. *Turkish Online Journal of Educational Technology-TOJET*, *11*(4), 273-282.

Cannady, M. A., Greenwald, E., & Harris, K. N. (2014). Problematizing the STEM pipeline metaphor: Is the STEM pipeline metaphor serving our students and the STEM workforce? *Science Education*, *98*(3), 443–460. https://doi.org/10.1002/sce.21108

Chai, C. S. (2019). Teacher professional development for science, technology, engineering and mathematics (STEM) education: A review from the perspectives of technological pedagogical content (TPACK). *Asia-Pacific Education Researcher (Springer Science & Business Media B.V.)*, *28*(1), 5–13. https://doi.org/10.1007/s40299-018-0400-7

Connelly, L. M. (2016). Trustworthiness in qualitative research. *Medsurg Nursing*, *25*(6), 435-437.

Calisici, H., & Sümen, Ö. Ö. (2018). Metaphorical perceptions of prospective teachers for STEM education. *Universal Journal of Educational Research, 6*(5), 871-880.

Cevik, M. (2017). Content analysis of STEM-focused education research in Turkey. *Journal of Turkish Science Education (TUSED), 14*(2), 12-26.- doi:10.12973/tused.10195a

Cevik, M., & Özgünay, E. (2018). STEM Education through the Perspectives of Secondary Schools Teachers and School Administrators in Turkey. *Asian Journal of Education and Training, 4*(2), 91-101.

Chute, E. (2009). STEM education is branching out: Focus shifts from making science, math accessible to more than just brightest. *Pittsburg Post-Gazette*. Retrieved October 14, 2018, from http://www.post-gazette.com/pg/09041/947944-298.stm

Corlu, M. S., Capraro, R. R., & Capraro, M. M. (2014). Introducing STEM education: implications for educating our teachers for the age of innovation. *Education & Science / Egitim ve Bilim*, 39(171), 74-85.

Cranston, N. (2013). School leaders leading: Professional responsibility not accountability as the key focus. *Educational Management Administration & Leadership,41*(2), 129-142.

Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches*. Thousand Oaks, CA: Sage.

Cuban, L. (2001). *Oversold and underused: Computers in the classroom*. Cambridge, MA: Harvard University Press

Daugherty, M. K. (2013). The prospect of an" A" in STEM education. *Journal of STEM Education: Innovations and Research,14*(2).

Dewey J (1916) *Democracy and education* The Free Press, New York

Duckworth, E. (1964). Piaget rediscovered. *The Arithmetic Teacher, 11*(7), 496-499. Retrieved June 18, 2018 from http://www.jstor.org/stable/41186862

Durkheim, E. (2006). Education: its nature and its role. In Hugh Lauder et al. (Ed.). *Education, globalization, and social change* (pp.76-87). New York : Oxford University Press.

Edmonds, R. (1979). Effective schools for the urban poor. *Educational leadership, 37*(1), 15 24.

Einstein, A. (1931). On Education. *Ideas and Opinions*. Retrieved June 18, 2018 from https://www.cse.iitm.ac.in/~kalyantv/pdf/on_edu.pdf

English, L.D. (2016). STEM education K-12: Perspectives on integration. *International Journal of STEM education, 3*(3), 3-8. doi: 10.1186/s40594-016-0036-1

Fayer, S., Lacey, A. and Watson, A.. (2017). *STEM occupations: Past, present, and future*. [online] Bureau of Labor Statistics. Retrieve 29 November,2018 from https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/pdf/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.pdf

Flanagan, L., & Jacobsen, M. (2003). Technology leadership for the twenty-first century principal. *Journal of educational administration, 41*(2), 124-142.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2015). *How to design and evaluate research in education* (9th Ed.). New York: McGraw-Hill Humanities/Social Sciences/Languages.

Freire, P. (1976). *Education, the practice of freedom*

Freire, P. (1992). The purpose of education (UIE Reports No.6). *The 40th Anniversary of the UNESCO Institute for Education*.

Gardner, D. (1983). *A nation at risk: the imperative for educational reform. An open letter to the American people. A report to the nation and the secretary of education.* Government Printing Office, Washington.

Garibay, J. C. (2015). STEM students' social agency and views on working for social change: Are STEM disciplines developing socially and civically responsible students?. *Journal of Research in Science Teaching, 52*(5), 610-632.

Geek. (n.d.). In *Cambridge Dictionary*. Retrieved January 10, 2019 from https://dictionary.cambridge.org/dictionary/english/geek#dataset-cacd

Geng, J., Jong, M. S. Y., & Chai, C. S. (2019). Hong Kong teachers' self-efficacy and concerns about STEM education. *The Asia-Pacific Education Researcher, 28*(1), 35-45.

Ginn, W.Y. (n.d) Jean Piaget-intellectual development. Retrieve June 19, 2018 from http://www.sk.com.br/sk-piage.html

Gokçe, F. F. (2009). Behaviour of Turkish Elementary School Principals in the Change Process: An Analysis of the Perceptions of Both Teachers and School Principals. *Educational Management Administration & Leadership, 37*(2), 198-215.

Goldring, E. B., & Pasternack, R. (1994). Principals' coordinating strategies and school effectiveness. *School effectiveness and school improvement, 5*(3), 239-253

Gouda, J., Chandra Das, K., Goli, S., & Maikho Apollo Pou, L. (2013). Government versus private primary schools in India: An assessment of physical infrastructure, schooling costs and performance. *International Journal of Sociology and Social Policy, 33*(11/12), 708-724.

Grek, S. (2009). Governing by numbers: The PISA 'effect'in Europe. *Journal of education policy, 24*(1), 23-37.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research, 2*(163-194), 105.

Gutek, G. L. (2009). *New perspectives on philosophy and education*. Columbus, OH: Pearson.

Gumus, E., & Bellibas, M. S. (2016). The effects of professional development activities on principals' perceived instructional leadership practices: Multi-country data analysis using TALIS 2013. *Educational Studies, 42*(3), 287-301. doi:10.1080/03055698.2016.1172958

Gur, B. S., Celik, Z., & Ozoğlu, M. (2012). Policy options for Turkey: a critique of the interpretation and utilization of PISA results in Turkey. *Journal Of Education Policy, 27*(1), 1-21. doi:10.1080/02680939.2011.595509

Hallinger, P. (2005). Instructional leadership and the school principal: A passing fancy that refuses to fade away. *Leadership and Policy in Schools, 4*, 1-20.

Hallinger, P., & Heck, R. H. (1996). Reassessing the principal's role in school effectiveness: A review of empirical research, 1980-1995. *Educational administration quarterly*, *32*(1), 5-44.

Hallinger, P., & J. Murphy. (1985). Assessing the instructional management behavior of principals. *The Elementary School Journal, 86*(2), 217 247.

Hallinger, P., & Murphy, J. (1986). The social context of effective schools. *American Journal of Education, 94*(3), 328–355.

Hanushek, E.A.(2011) The economic value of education and cognitive skills. *Economics of Education Review,* 30(3), 466-479

Hanushek, E.A.(2018). Every state's economic future lies with school reform. *American Enterprise Institute.* Retrieve June 25, 2018 from http://www.aei.org/publication/every-states-economic-future-lies-with-school-reform/

Havice, W., Havice, P., Waugaman, C., & Walker, K. (2018). Evaluating the effectiveness of integrative STEM education: teacher and administrator professional development. *Journal of Technology Education, 29*(2), 73–90. Retrieved in May 15, 2019 from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1182375&site=ehost-live

Heggen, S., Omokaro, O., & Payton, J. (2012, October). Mad science: increasing engagement in STEM education through participatory sensing. In *Proc. of the Sixth International Conference on Mobile Ubiquitous Computing, Systems, Services and Technologies*.

Herro, D., & Quigley, C. (2017). Exploring teachers' perceptions of STEAM teaching through professional development: implications for teacher educators. *Professional Development in Education, 43*(3), 416-438. doi:10.1080/19415257.2016.1205507

Hoeg, D. & Bencze, L. (2017). Rising Against a Gathering Storm: A Biopolitical Analysis of Citizenship in STEM Policy. *Cultural Studies of Science Education, 12*, 843-861.

Holmegaard, H. T., Madsen, L. M., & Ulriksen, L. (2014). To choose or not to choose science: Constructions of desirable identities among young people considering a STEM higher education programme. *International Journal of Science Education, 36*(2), 186-215.

Holmlund, T. D., Lesseig, K., & Slavit, D. (2018). Making sense of "STEM education" in K-12 contexts. *International journal of STEM education, 5*(1), 32.

Honeypot. (2018). Women in Tech Index 2018. Retrieved from https://www.honeypot.io/women-in-tech-2018/

Kanadli, S. (2019). A meta-summary of qualitative findings about STEM education. *International Journal of Instruction, 12*(1), 959–976. Retrieved June 10, 2019 from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1201183&site=ehost-live

Kanz, H. (1993). Immanuel Kant.*Education Paris, UNESCO: International Bureau of Education*,*23*(3/4), 789-806.

Kloser, M., Wilsey, M., Twohy, K. E., Immonen, A. D., & Navotas, A. C. (2018). "We do STEM": Unsettled conceptions of STEM education in middle school STEM classrooms. *School Science and Mathematics, 118*(8), 335-347.

Kondakçi, Y. (2005).*Practice-based continuous change process: a longitudinal investigation of an organizational change process in a higher education organization.*

Kondakci, Y., Kulakoglu, B. (2018). *STEM uygulamaları ve eğitim yönetimi*. XIII. Ulusal Eğitim Yönetimi Kongresi, Sivas, Türkiye

Kondakci, Y., Orucu, D., Oguz, E., & Beycioglu, K. (2019). Large-scale change and survival of school principals in Turkey. *Journal of Educational Administration and History*, 1-15.

Kumar, S., Ahmad ,S. (n.d). Meaning, aims and process of education. Retrieve June 7 ,2018 from https://sol.du.ac.in/solsite/Courses/UG/StudyMaterial/16/Part1/ED/English/SM-1.pdf

Küskü, F., Özbilgin, M., & Özkale, L. (2007). Against the tide: Gendered prejudice and disadvantage in engineering. *Gender, Work & Organization, 14*(2), 109-129.

Lanchman, R. (2017). *STEAM not STEM: Why scientists need arts training.* Retrieved January 21, 2018 from https://theconversation.com/steam-not-stem-why-scientists-need-arts-training-89788

Land, M. H. (2013). Full STEAM ahead: The benefits of integrating the arts into STEM. *Procedia Computer Science, 20*, 547-552.

Lawlor, R. (2015). Delaying Obsolescence. Science and Engineering Ethics, *21*(2), 401-427

Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic inquiry*. Newbury Park, CA: Sage

Lochmiller, C. R. (2016). Examining administrators' instructional feedback to high school math and science teachers. *Educational Administration Quarterly, 52*(1), 75-109. doi:10.1177/0013161X15616660

Lu, C., Tsai, C. C., & Wu, D. (2015). The role of ICT Infrastructure in its application to classrooms: a large scale survey for middle and primary schools in China. *Journal of Educational Technology & Society, 18*(2), 249-261.

Lunenburg, F. C., & Ornstein, A. C. (2004). Educational Administration: Concepts and Practices, 4th edn. (Belmont, CA: Wadsworth/Thomson Learning).

Magnuson, S. (2018). The STEM pipeline will only grow smaller. *National Defense, 103*(778), 8. Retrieved January 22, 2019 from http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=131710144&site=ehost-live&authtype=ip,uid

Mihelich, J. A., Sarathchandra, D., Hormel, L., Storrs, D. A., & Wiest, M. M. (2016). Public understanding of science and K-12 STEM education outcomes: effects of Idaho parents' orientation toward science on students' attitudes toward science. *Bulletin of Science, Technology & Society, 36*(3), 164-178. doi:10.1177/0270467616687217

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook.*

Milli Eğitim Bakanlığı Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü (2016). *STEM Eğitimi Raporu*. Retrieved January 16, 2018 from http://yegitek.meb.gov.tr/STEM_Egitimi_Raporu.pdf

Ministry of National Education. (2016). Millî Eğitim Bakanlığı ortaöğretim kurumları yönetmeliği. Retrieved January 28, 2018, from https://ogm.meb.gov.tr/meb_iys_dosyalar/2016_11/03111224_ooky.pdf

Ministry of National Education. (2018a). National education statistics, formal education. Official Statistics Programme, Ankara.

Ministry of National Education. (2018b). Sinavla öğrenci alacak ortaöğretim kurumlarina ilişkin merkezî sinav başvuru ve uygulama kilavuzu. Retrieved January 25, 2018, from https://www.meb.gov.tr/sinavlar/dokumanlar/2018/MERKEZI_SINAV_BASVURU_VE_UYGULAMA_KILAVUZU.pdf

Musk, E. (2014). *All Our Patent Are Belong to You.* Retrieved January 16, 2018 from https://www.tesla.com/blog/all-our-patent-are-belong-you.

Nerd. (n.d.). In *Cambridge Dictionary.* Retrieved January 10, 2019 from https://dictionary.cambridge.org/dictionary/english/nerd#dataset-cacd

Neumerski, C. (2012). Rethinking instructional leadership, a review. *Educational Administration Quarterly, 49*(2), 310-347. doi:10.1177/001316112456700

Nir, A., Kondakci, Y., & Emil, S. (2018). Travelling policies and contextual considerations: on threshold criteria. *Compare: A Journal of Comparative and International Education, 48*(1), 21-38.

Noonan, R. (2017). *Women in STEM: 2017 update.* U.S. Department of Commerce, Economics and Statistics Administration

North, D.C. (1990). *Institutions, institutional change, and economic performance.* Cambridge University Press, New York.

NYC Department of Education. (n.d.). NYC STEM education framework. Retrieved 20 March, 2018 from http://schools.nyc.gov/NR/rdonlyres/DE2FC1DE-5FB8-474F-BD27-D75FF70EF610/0/STEMframework_WEB1.pdf

Okubo, Y., Matsushita, S., Takakuwa, Y., Yoshioka, T., & Nitta, K. (2016). Longitudinal PBL in undergraduate medical education develops lifelong-learning habits and clinical competencies in social aspects. *The Tohoku journal of experimental medicine, 238*(1), 65-74.

Ozturk, G. (2018). STEM eğitimdeki geri kalmışlıktan çıkış reçetesi değildir. Retrieved February 7, 2018 from Eğitim ve Eğitim: http://www.egitimveegitim.com/soz_egitimcilerde/3008-yrd_doc_dr_gokhan_ozturk.html

ÖSYM. (2019). *2019 YKS sayısal bilgiler*. Retrieved in August 6, 2019 from https://dokuman.osym.gov.tr/pdfdokuman/2019/YKS/sayisalbilgiler18072019.pdf

Partnership for 21st Century Learning. (2007). Framework for 21st century learning. Retrieve December 20, 2018, from http://www.p21.org/storage/documents/docs/P21_framework_0816.pdf

Perception. In *Oxford Dictionary*. Retrieved June 24, 2018 from https://en.oxforddictionaries.com/definition/perception

Piaget, J., & Cook, M. T. (1952). *The origins of intelligence in children.* New York, NY: International University Press.

Plank, D. N. (2011). Minding the gap between research and policy making. *The SAGE handbook for research in education: Pursuing ideas as the keystone of exemplary inquiry*, 43-58.

Price-Mitchell M. (2014). What is education? Insights from the world's greatest minds, *Psychology Today*. Retrieve June 7, 2018 from https://www.psychologytoday.com/us/blog/the-moment-youth/201405/what-is-education-insights-the-worlds-greatest-minds

Rappleye, J. (2009). The politics of structural education reform. *Comparative Education Review*, *53*(2), 304–307. Retrieved December 20, 2018 from http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=39553814&site=ehost-live&authtype=ip,uid

Raza, R.(2018, April 9). Exponential growth and the energy business model [Blog post]. Retrieved January 11, 2019 from https://iconsofinfrastructure.com/exponential-growth-and-the-energy-business-model/

Robnett, R. D., & Leaper, C. (2013). Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest. *Journal of Research on Adolescence, 23*(4), 652-664.

Sarac, Y.(2018). YÖK başarı bursunun kapsamı genişletildi. *The Council of Higher Education.* Retrieved December 19, 2018 from https://www.yok.gov.tr/Sayfalar/Haberler/yok-basari-bursu-kapsami.aspx

Sellar, S., & Lingard, B. (2013). The OECD and global governance in education. *Journal of Education Policy*, *28*(5), 710-725.

Saltmarsh, J. (1996). Education for critical citizenship: John Dewey's contribution to the pedagogy of community service learning. *Michigan Journal of Community Service Learning, 3*(1), 13-21.

Sanders M (2009) STEM, STEM education, STEM mania. *Technol Teach, 68*(4):20–26

Steiner-Khamsi, G. 2004. Blazing a trail for policy theory and practice. In *The global politics of educational borrowing and lending,* ed. G. Steiner-Khamsi, 201–20. New York: Teachers College Press.

The Council of Higher Education. (2017). Number of graduates by classification of fields of education and training, 2015 - 2016. Retrieved June 10, 2019 from https://istatistik.yok.gov.tr/

The Council of Higher Education. (2018). Number of Graduates by Classification of Fields of Education and Training, 2016 - 2017. Retrieved June 10, 2019 from https://istatistik.yok.gov.tr/

The Council of Higher Education. (2019). Number of Graduates by Classification of Fields of Education and Training, 2017 - 2018. Retrieved June 10, 2019 from https://istatistik.yok.gov.tr/

The Council of Higher Education. (n.d). Yükseköğretim Kurulu Başkanlığından Verilecek Burslar. Retrieve December 19, 2018 from http://www.yok.gov.tr/documents/10279/15601/YOK_tarafindan_verilen_burslar.pdf

Thibaut, L., Ceuppens, S., De Loof, H., De Meester, J., Goovaerts, L., Struyf, A., ... & Hellinckx, L. (2018). Integrated STEM education: A systematic review of instructional practices in secondary education. *European Journal of STEM Education, 3*(1), 2.

Türkiye'nin Mühendis Kızları. (n.d). In *Türkiye'nin mühendis kızları.* Retrieve December 19, 2018 from http://www.turkiyeninmuhendiskizlari.com/

UK Essays. (November 2018). *Teaching values in the classroom*. Retrieved December 13, 2018 from https://www.ukessays.com/essays/education/replace-an-empty-mind-with-an-open-one-education-essay.php?vref=1

UNESCO .(Ed). (1992). *International conference on education. recommendation no. 78 to ministries responsible for education and culture concerning the contribution of education to cultural development.* Geneva, *14-19 September 1992.* UNESCO: International Bureau of Education. Retrieved June 11, 2018 from http://www.unesco.org/education/pdf/REC_78_E.PDF)

van den Hurk, A., Meelissen, M., & van Langen, A. (2019). Interventions in education to prevent STEM pipeline leakage. *International Journal of Science Education, 41*(2), 150-164.

Wade-Leeuwen, B., Vovers, J., Silk, M. (2018). *Explainer: what's the difference between STEM and STEAM?* Retrieved December 14, 2018 from https://theconversation.com/explainer-whats-the-difference-between-stem-and-steam-95713

Wahlstrom, K. L., & Louis, K. S. (2008). How teachers experience principal leadership: The roles of professional community, trust, efficacy, and shared responsibility. *Educational administration quarterly*, *44*(4), 458-495.

Wang, X. (2013). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal, 50*(5), 1081-1121.

Xie, Y., Fang, M., & Shauman, K. (2015). STEM education. *Annual review of sociology, 41*, 331-357.

Vasquez, J. A. (2015). STEM--beyond the acronym. *Educational Leadership*, *72*(4), 10-15.

Yildirim, A., & Simsek, H. (2006).*Sosyal bilimlerde nitel arastirma yöntemleri*. Seckin Yayıncılık

APPENDICES

APPENDIX A: GÖRÜŞME SORULARI / INTERVIEW QUESTIONS

1. Okuldaki öğrenme ortamını nasıl tanımlarsınız?
2. Diğer okullardan farklı olarak okulunuzda ne gibi yöntemler uygulanmaktadır?
3. Amerika'dan dünyaya yayılan bir eğitimi akımı olan STEM, fen bilimleri, matematik, teknoloji ve mühendislik konularını bir araya getirerek öğretimde interdisipliner yaklaşımı benimseyen bir eğitim hareketidir. Bu hareketle ilgili ne düşünüyorsunuz?
4. Okulun vizyonu ve hedefleri ile STEM eğitimi arasındaki uyum var mıdır? Varsa nasıl?
5. Okulun misyon vizyon ve hedeflerinde şu anki eğitim uygulamalarına katkıyı ne şekilde yapıyorsunuz?
6. STEM eğitimini uygulama örnekleriniz var mı? Okulunuz STEM eğitimini hangi uygulamalarla eğitim öğretim ortamına aktarıyor?
    a. STEM hareketini okulunuzda yaygın bir şekilde uygulamak için neler yapıyorsunuz?
7. Sizce STEM eğitim hareketinin kapsadığı eğitsel alanlar hangileridir? (analitik düşünme, problem çözme vb.)
8. Müdür olarak STEM eğitimindeki rolünüzü nasıl tanımlıyorsunuz?

a. Öğretmen-öğretmen ve öğretmen müdür iletişiminin süreçteki rolü nedir?
b. Sizin bu eğitim sürecindeki liderlik rolünüz nedir?
c. Bu süreçte öğretmenlere nasıl liderlik ediyorsunuz?

9. Öğrencilerin yapılan uygulamalara yönelik tutumları nedir?
10. Öğretmenlerin yapılan uygulamalara yönelik tutumları nedir?
11. Öğretmenlerin sürece katılımını etkileyen faktörler nelerdir?
12. Bu süreçte ihtiyaç duyulan / okulun ihtiyacı olan kaynaklar nelerdir? Kaynaklarınız yeterli mi?
13. STEM eğitiminin uygulanabilirliği, gerçekliği bakımından Türk eğitim sistemine katkısını nasıl değerlendirirsiniz? Türkiye'ye katkısını nasıl değerlendirirsiniz?
    a. STEM'in eğitimde eksik bıraktığı alanlar nedir?
    b. STEM eğitimdeki tüm ihtiyaçlara cevap verebilir mi?
14. Avrupa ve Amerika'da bu yükselen eğitim hareketine karşı çıkan araştırmacı eğitimci topluluğu var. Nedenleri ise eğitimin sadece matematik ve fen bilimlerinden ibaret olmadığı bu konuları merkeze alan bir yaklaşımda sanat ve beşeri bilimlerin rolünün olmadığı yönünde. Bu yüzden, eğitim ortamlarına matematik fen teknoloji ve mühendislik alanlarının yanı sıra sanat becerilerinin de bu süreçlere dahil edilmesi gerektiğini savunuyorlar. STEAM eğitimi ile ilgili ne düşünüyorsunuz? Sanat ve beşeri bilimlerin STEM eğitimine katkısı var mıdır? Varsa nasıl katkı sağlamaktadır?
    a. STEAM eğitiminde önem verilen sanat ve beşeri bilimler (arts and humanities) sizin okulunuzdaki uygulamalarda nasıl bir yere sahip?

APPENDIX B:HUMAN SUBJECTS ETHICS COMMITTEE PERMISSION

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

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ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
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uearn@metu.edu.tr

Sayı: 28620816/ 333

06 Haziran 2018

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Doç. Dr. Yaşar KONDAKÇI

Danışmanlığını yaptığınız yüksek lisans öğrencisi Büşra KULAKOĞLU' nun **"Okul Müdürlerinin STEM Eğitimi Algıları "** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2018-EGT-090** protokol numarası ile **08.06.2018 - 03.03.2019** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan V

Prof. Dr. Ayhan SOL
Üye

Prof. Dr. Ayhan Gürbüz DEMİR
Üye

Doç. Dr. Yaşar KONDAKÇI
Üye

Doç. Dr. Zana ÇITAK
Üye

Doç. Dr. Emre SELÇUK
Üye

Dr. Öğr. Üyesi Pınar KAYGAN
Üye

APPENDIX C: THE LEGAL PERMISSION OF PROVINCIAL DIRECTORATE OF NATIONAL EDUCATION

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

Sayı : 14588481-605.99-E.13517286 19.07.2018
Konu : Araştırma İzni

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi: a) MEB Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2017/25 nolu Genelgesi.
b) 27/06/2018 Tarihli ve E.18 sayılı yazınız.

Üniversiteniz Eğitim Yönetimi ve Planlaması programı yüksek lisans öğrencisi Büşra Kulakoğlu'nun **"Okul Müdürlerinin STEM Algısı"** konulu uygulama talebi Müdürlüğümüzce uygun görülmüş ve uygulamanın yapılacağı İlçe Milli Eğitim Müdürlüklerine bilgi verilmiştir.

Görüşme formunun (4 sayfa) araştırmacı tarafından uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde bir örneğinin (cd ortamında) Müdürlüğümüz Strateji Geliştirme (1) Şubesine gönderilmesini rica ederim.

Vefa BARDAKCI
Vali a.
Milli Eğitim Müdürü

Güvenli Elektronik İmzalı
Aslı İle Aynıdır.
...../7...../2018

Adres: Emniyet Mah. Alparslan Türkeş Cad. 4/A
Yenimahalle/ANKARA
Elektronik Ağ: www.meb.gov.tr
e-posta: istatistik06@meb.gov.tr

Bilgi için: D. KARAGÜZEL
Tel: 0 (312) 221 02 17
Faks: 0 (312) 221 02 16

Bu evrak güvenli elektronik imza ile imzalanmıştır. https://evraksorgu.meb.gov.tr adresinden 6785-d12e-3107-adf0-579a kodu ile sorgulanabilir.

APPENDIX D: INFORMED CONSENT FORM

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu çalışma ODTÜ Eğitim Bilimler Bölümü Eğitim Yönetimi ve Planlaması Programı öğrencisi Büşra Kulakoğlu tarafından Doç. Dr.Yaşar Kondakçı danışmanlığında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın Amacı Nedir?

Okul müdürlerinin Bilim, Teknoloji, Mühendislik, Matematik (BİLTEMM/ STEM) eğitimi hakkındaki görüş ve uygulamalarını incelemektir.

Bize Nasıl Yardımcı Olmanızı İsteyeceğiz?

Araştırma yüz yüze görüşme yolu ile gerçekleştirilecektir. Okul müdürleri katılımcı olarak davet edilecek, katılmak isteyenlerle toplamda yaklaşık 40 dakika sürecek mülakatlar yapılacaktır. Çalışmada sizden istenen sorulara düşüncelerinizi yansıtarak cevap vermenizdir. Katılımcının izin vermesi durumunda ses kaydı alınacaktır, izin vermemesi durumunda görüşmede not alınacaktır.

Katılımınızla ilgili bilmeniz gerekenler:

Bu çalışmaya katılmak tamamen gönüllülük esasına dayalıdır. Herhangi bir yaptırıma veya cezaya maruz kalmadan çalışmaya katılmayı reddedebilir veya çalışmayı bırakabilirsiniz. Araştırma esnasında cevap vermek istemediğiniz sorular olursa boş bırakabilirsiniz.

Araştırmaya katılanlardan toplanan veriler tamamen gizli tutulacak, veriler ve kimlik bilgileri herhangi bir şekilde eşleştirilmeyecektir. Katılımcıların isimleri bağımsız bir listede toplanacaktır. Ayrıca toplanan verilere sadece araştırmacılar ulaşabilecektir. Bu araştırmanın sonuçları bilimsel ve profesyonel yayınlarda veya eğitim amaçlı kullanılabilir, fakat katılımcıların kimliği gizli tutulacaktır.

Riskler:

Çalışmanın herhangi bir riski bulunmamaktadır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Çalışmayla ilgili soru ve yorumlarınızı kyasar@metu.edu.tr ya da busraku@metu.edu.tr adresinden iletebilirsiniz.

Yukarıdaki bilgileri okudum ve bu çalışmaya tamamen gönüllü olarak katılıyorum.
(Formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

İsim Soyad Tarih İmza

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APPENDIX E: TURKISH SUMMARY / TÜRKÇE ÖZET

STEM EĞİTİMİNDE BİLİNMEYEN ALAN: OKUL YÖNETİCİLERİNİN STEM EĞİTİMİ HAKKINDAKİ GÖRÜŞLERİ

Giriş

STEM ya da Türkiye'de bilinen adıyla BİLTEMM eğitimi, fen bilimleri (Science), teknoloji (Teknoloji), mühendislik (Engineering) ve matematik (Mathematics) alanlarının akroniminden oluşan ve bu alanların disiplinler arası bir yaklaşımla eğitim ortamlarında uygulanması amacıyla ortaya çıkmış bir eğitim hareketidir. Ortaya çıkışı Amerika Birleşik Devletleri'nde olan bu eğitim hareketinin Türkiye'deki ilk adımları Amerika Birleşik Devletleri'nde doktorasını tamamlayan akademisyenlerin ülkeye dönüşü ile atılmıştır. Türkiye'de STEM eğitim hareketi özellikle akademide ve özel okullarda yankı bulmuştur (Öztürk, 2018). STEM eğitiminin bu şekilde bir trend haline gelmesinin ardından, ulusal düzeyde bir devlet politikası olarak ele alınması Milli Eğitim Bakanlığı (2016) tarafından yayımlanan STEM Eğitimi Raporu ile olmuştur. Raporda STEM eğitimi ile ilgili herhangi bir eylem planının bulunmadığı belirtilmiş buna karşılık 2015-2019 stratejik planında bu konuya ilişkin bazı amaçların oluşturulduğundan bahsedilmiştir. Ayrıca üniversitelerde STEM eğitimi ile ilgili yapılan çalışmaların ve projelerin azlığı da vurgulanmıştır (MEB, 2016).

Dünyada birçok çalışmaya konu olan STEM eğitimi, Türkiye'de de çalışılan bir konudur. Çevik (2017) tarafından yapılan çalışmaya göre 2014-2016 yılları arasında bu alanla ilgili otuz dört araştırma bulunmaktadır. Konuyu öğretmen adaylarıyla, öğrencilerle ve az da olsa öğretmenlerle yapılan araştırmalarla irdeleyen araştırmacılar genellikle STEM eğitiminin değerlendirilmesi, mühendislik ve STEM, fen bilimleri ve STEM, STEM görüşleri ve STEM eğitimine olan eğilim açılarından incelemişlerdir. Yapılan çalışmaların çeşitliliğinin aksine STEM eğitiminin okul

müdürleri veya okul yöneticilerinden toplanmış verilerle incelenmesi konusunda küresel çaptaki eksiklik Türkiye'de de görülmektedir.

STEM eğitiminin eğitim-öğretim ortamlarına aktarılması konusundaki eksiklikler ve engeller, konunun tam olarak açıklık getirilmemiş bir eğitim hareketi olmasından kaynaklanmaktadır. Ayrıca ülkemizde STEM eğitiminin uygulanması için altyapı ihtiyaçlarının karşılanması ve okul ortamlarının uygulamalara uygun hale getirilmesi gerekmektedir. Bu eksik ve engeller düşünüldüğünde, sonuçsuz kalan uygulamalar etrafında şekillendirilmeye çalışılan STEM eğitimi, Batı ülkelerinden yapılan daha önceki diğer politika ithalleri gibi, geçici bir hevesin ötesine geçememektedir. Her yönden araştırma ve inceleme yapılmasını gerektiren STEM eğitiminin Türk eğitim sistemine uygunluğu incelenmeden bu eğitim hareketine cömert yatırımlar yapılmaktadır.

Araştırmanın Amacı

Türk eğitim sistemindeki değişim ve gelişimlerin uygulanması, fark edilme ve yerleştirilmesi için okul liderliği önemli bir yere sahiptir. (Kondakçı vd., 2019). Bu yüzden başka değişim süreçlerinde olması gerektiği gibi STEM eğitiminin de liderlik açısından değerlendirilmesi gerekmektedir. Bu durumdan hareketle, bu çalışmanın amacı, Ankara ilinde özel program uygulayan proje liseleri olarak adlandırılan ya da ortaöğretime geçiş sınavının sonuçlarına göre öğrenci alan liselerde görev yapan okul yöneticilerinin bu konudaki düşüncelerini ve bu konuya yaklaşımlarını anlamaktır. Bu sayede STEM eğitimi süreçleri okul yöneticilerinin gözünden irdelenecektir. Bu amaçla, müdürlerle dört alanı kapsayan NYC STEM çerçevesinden yola çıkılarak hazırlanan görüşme protokolü kullanılarak yüz yüze görüşmeler gerçekleştirilmiştir. Bahsi geçen dört alan (i) okul vizyonu ve başarı için gerekli olan yapı, (ii), STEM eğitim programı, öğretimi ve değerlendirmesi, (iii), stratejik ortaklık, ve (iv) üniversitelerde STEM ve STEM kariyer planlaması için gerekli K-12 seviyesinde plan ve hazırlıklardır. STEM eğitiminin okullarda uygulanmasına yönelik oluşturulan ve uygulama için gerekli olan önemli noktalara değinen bu temel çerçeveyi kullanarak oluşturulan görüşme sorularıyla yapılan çalışmanın amacı okul yöneticilerinin STEM eğitimi algılarını, deneyimlerini ve süreçteki rollerini anlamaktır. Bu bağlamda çalışmanın araştırma soruları şu şekildedir:

1. Okul yöneticileri 2010ların eğitim trendi olan STEM eğitimini nasıl algılamaktadır?
2. Okul yöneticilerinin STEM eğitimi ile ilgili deneyimleri nelerdir?
3. Okul yöneticileri okullarındaki STEM eğitimi uygulamalarındaki rollerini nasıl tanımlamaktadırlar?

Alanyazın Taraması

Alanyazın taramasında ilk olarak ele alınan konu, STEM eğitiminin Amerika Birleşik Devletleri'nde ortaya çıkışında rol oynayan etkenler ve ortaya çıkış nedenleridir. Daha sonrasında Türkiye'de nasıl ortaya çıktığından ve bu konuda MEB tarafından atılan adımlardan bahsedilmiştir. STEM eğitimi dünyada olduğu gibi Türkiye'de de yankı bulan bir konu olmasına rağmen STEM eğitimiyle ilgili tanımsal ve kavramsal açılardan eksiklikler ve ikilikler vardır. Bu durum alanyazında ortaya çıkan bir diğer STEM eğitimi konusudur. Tanımsal ve kavramsal eksikliklerin yanı sıra STEM alanlarında kariyer seçmeleri için bireylerin eğitimlerinin ilk yıllarından itibaren STEM eğitimine tabi tutulması gerektiğini savunan STEM hattı (STEM pipeline) kavramıyla ilgili alanyazındaki tartışmalara da alanyazın taraması kısmında yer verilmiştir. Ayrıca, tüm bu eksiklikler, uygulamalar, ortaya çıkış hikâyelerinden sonra STEM eğitiminin bir politika sorunu olarak ele alınması gerektiğinden bahseden çalışmalara ve politika ithalinde dikkat edilmesi gereken hususlara da değinilmiştir. STEM eğitimi bir eğitim politikası olmasının yanı sıra eğitimde eşitlik konularını da gündeme getirmektedir. Alanyazında bu konu dezavantajlı gruplar, kadınlar, okullar arası farklılıklardan oluşan eşitsizlikler, STEM alanlarında çalışan bireylerin zeki ama asosyal (nerd, geek) olarak görülmesinden kaynaklanan kariyer seçim değişiklikleri gibi hususlarda ele alınmıştır. Tüm bunların yanında teknolojik gelişmelerin doğrusal değil üstel (exponential) bir büyümeyle yaşandığı 21. yüzyılda, STEM eğitiminin sosyal hayat becerileri ve iş bulma olanaklarını arttırmak açısından gerekli olan bilgi ve becerilerin geliştirilmesinde rol oynadığına dair çalışmalar alanyazında mevcuttur. Yaşadığımız yüzyılda STEM eğitimin bilgi ve beceri geliştirme konusunda getirdiği avantajların yanında STEM eğitiminin eksik bıraktığı alanlardan da söz edilmektedir. Eksik kalan alanların geliştirilmesi amacıyla STEM eğitimi yerine daha yeni bir konsept olan STEAM eğitiminin uygulanması fikri oraya atılmıştır. Bu eğitim yaklaşımda STEM eğitimine sanat ve beşeri bilimlerin eklenmesi ve bireylere etik,

sorumluluk ve estetik gibi konularda katkı sağlanması gerektiği vurgulanmaktadır. Tüm bunlara ek olarak, konu hakkında alanyazında yapılan çalışma olmasa da STEM eğitiminin uygulanması için okul yöneticilerinin üstlenmesi gereken rollerden bahsedilmiştir. Alanyazındaki eksiklikten dolayı konu okul müdürlerinin okullardaki teknoloji uygulamalarında üstlendikleri liderlik rollerinden ve okul müdürlerinin değişim süreçlerindeki rollerinden bahsedilerek STE eğitimi uygulamalarında üstlenebilecekleri rollerle bağdaştırılmıştır.

Metot

Nitel araştırma metodu "deneyim"lere, "anlam"a ve "anlamlandırma"ya odaklanır (Bogdan & Biklen, 1998; Patton, 2002). Bu çalışmada bireylerin deneyimleri ile oluşturdukları düşüncelere, hareketlere ve varsayımlara odaklanan fenomenoloji çalışma deseni kullanılmıştır (Creswell, 2007, p.57; Patton, 2002, p.104). Çalışmanın amacı okul yöneticilerinin STEM eğitimi ile ilgili algılarını, deneyimlerini ve rollerini derinlemesine anlamak olduğundan nitel araştırma yöntemi tercih edilmiştir.

Çalışma grubu

Çalışmanın katılımcıları Ankara ilinde bulunan liselerde çalışan okul yöneticilerinden oluşmaktadır. Katılımcıların lise düzeyinde okul yöneticiliği yapan kişilerden seçilmiş olmasının nedeni lise seviyesinin üniversitede okunacak bölüm ve kariyer seçiminde kritik bir dönem olmasından kaynaklanmaktadır. Ankara ilindeki liselerden katılımcı okulları seçme kriteri ise liselerin Milli Eğitim Bakanlığı tarafından her sene yapılan Lise Giriş Sınavı (LGS) ile öğrenci alan liselerden olmalarıdır. LGS'nin önemi, değişen sınav sistemiyle birlikte, bu sınavla öğrenci alan liselerin yalnızca fen liseleri, sosyal bilimler liseleri ve Özel Program ve Proje Uygulayan Ortaöğretim Kurumları olmalarıdır (Milli Eğitim Bakanlığı, 2018b). Ankara ilinde bulunan toplam 795 liseden 82 tanesi bu kritere uymaktadır. Ölçüt örneklem yoluyla seçilen (Patton, 2002) bu okullarda aranan bir diğer kriter ise okulların STEM eğitimine yakın uygulamalar yapabilecek ve bu konuda eğilimi olan okullar olmalarıdır.

Okul türlerine karar verildikten sonra, on bir okul yöneticisi ile görüşmeler gerçekleştirilmiştir. Bu okul yöneticilerinden ikisi Fen Lisesi'nde, ikisi Anadolu ve İmam Hatip Lisesi'nde ve geri kalan yedisi Anadolu Lisesi'nde görev yapmaktaydı.

Lincoln ve Guba (1985)'ya göre araştırmalarda örneklem büyüklüğüne katılımcılardan alınan bilgilere göre karar verilmektedir. Bu yüzden, örneklemden alınan bilgilerin en yüksek noktaya ulaştığı ve artık alınan bilgilerin tekrar etmeye başladığı noktada veri toplama süreci sonlandırılmıştır (aktaran Patton, 2002).

Veri Toplama Araçları

Bu çalışmada iki tür veri toplama aracı kullanılmıştır. İlk veri toplama aracı görüşme protokolünün uygulanması yoluyla okul yöneticileriyle yapılan yüz yüze görüşmelerdir. Görüşme soruları, yarı yapılandırılmış görüşme tekniğine göre, on dört ana soru ve yedi alt sorudan oluşacak şekilde hazırlanmıştır (Appendix A) ve görüşme soruları ile ilgili iki akademisyenden uzman görüşü alınmıştır. Yapılan görüşmeler sırasında katılımcının bilgisi ve izni doğrultusunda ya ses kaydı alınmış ya da not tutulmuştur. Bu çalışmada nitel araştırmanın geçerlik ve güvenirliğini artırma yollarından biri olan 'veri toplama aracı çeşitleme yöntemi' kullanılmıştır. Bunun için kullanılan araç okulların internet siteleri ve stratejik planlarının incelenmesi yoluyla yapılan doküman analizidir. Doküman analizi sırasında, konuyla ilgisi olmayan duyuru, haber ve stratejik plan dokümanlarının göz ardı edilmesi için Miles ve Huberman (1994) tarafından belirtilen 'veri azaltımı tekniği' kullanılmıştır. STEM eğitimi ile ilgili olmayan dokümanlar bu şekilde elenmiştir.

Veri toplama süreci ve veri analizi

Görüşme sorularının hazırlanmasından sonra ODTÜ İnsan Araştırmaları Etik Kurulu'na Mayıs 2018'de başvurulmuş ve izin Haziran 2018'de alınmıştır (Appendix B). Sonrasında Ankara İl Milli Eğitim Müdürlüğü'nden Ağustos 2018'de gerekli izin alınmış ve görüşmelere başlanmıştır. On bir okul yöneticisiyle yapılan görüşmeler sonrasında veri toplama süreci görüşmeler açısından sonlandırılırmıştır. Doküman analizi görüşmeler sonlandırıldıktan sonra yapılmıştır. Veri toplama süreci Mart 2019'da bitmiştir. Veri analizi için kodlama tekniği kullanılmıştır ve bu süreçte MAXQDA 2018.2 uygulamasından yararlanılmıştır. Kodlama tekniği ile analiz edilen verilerden üç araştırma sorusu için toplam dokuz tema çıkmıştır. Veri analizi betimsel analiz ve içerik analizi olmak üzere iki ana analiz şekliyle gerçekleştirilmiştir.

Bulgular

Bu çalışmada Lise Giriş Sınavı sonuçlarına göre öğrenci alan liselerde görev yapan okul yöneticilerinin STEM eğitimiyle ilgili algıları incelenmiştir. Ayrıca okul yöneticilerinin okullarında yaşadıkları STEM eğitimi deneyimleri ile bu süreçlerdeki rolleri araştırılmıştır.

Genel olarak, STEM eğitiminin okulların stratejik planları ve misyon, vizyon cümlelerinde yer almadığı, içerik analizinden önce okullar ve müdürlerle ilgili yapılan betimsel analizde görülmüştür. Ayrıca görüşme yapılan tüm okul müdürlerinin okul yöneticiliği deneyimleri çok olmasına rağmen STEM eğitimi konusunda bilgilerinin kısıtlı olduğu veri analizi sonucunda ortaya çıkmıştır. Ek olarak, okulların altyapı açısından farklılık gösterdiği ve bazı okullarda FATİH projesi ile okullara getirilen altyapı uygulamalarının bile olmadığı görülmüştür.

Veri analizi sonucu üç araştırma sorusu için dokuz tema çıkmıştır. Bunlar ilk araştırma sorusu olan STEM algısı ile ilgili ortaya çıkan (1) tanımsal sorun, (2) STEM'e karşı STEAM, (3)STEM'in Türkiye'ye katkıları, (4)STEM'in (politika) eksikliği; ikinci araştırma sorusu olan okul yöneticilerinin STEM eğitimi deneyimleri ile ilgili ortaya çıkan (5) okulların durumu, (6) okullarda STEM eğitimi; ve son araştırma sorusu olan okul yöneticilerinin STEM eğitimindeki rolü ile ilgili ortaya çıkan (7) müdürlerin yardımcı rolü, (8) müdürlerin destekçi rolü, (9) müdürlerin motivasyon sağlama rolüdür.

Okul müdürleri STEM eğitiminin ne olduğu ile ilgili birbirinden farklı algılara sahiptir. Bu durumun nedeni STEM eğitimiyle ilgili bilgi eksikliği ya da yanlış anlaşılmalardan kaynaklanmaktadır. Kimisi STEM eğitiminin fen bilimleri, matematik ve hatta beden eğitimi dersi ile ilgili olabileceğini söylerken (P5), başka bir okul müdürü STEM eğitiminin bir yaşam felsefesi olarak değerlendirilebileceğinden bahsetmiştir (P10). STEM eğitiminin Türkiye'de çok anlaşılmadığını belirten ve sadece kodlama ve robotik olarak algılandığından bahseden bir okul müdürü de olmuştur (P1).

Tanımsal sorunlara ek olarak ve sanat ve beşeri bilimlerin STEM eğitimine yerleştirilmesi gerektiğini vurgulayan STEAM eğitimiyle ilgili de okul müdürlerinin

birbirlerinden farklı görüşleri bulunmaktadır. Bir okul müdürü bu alanların birlikte yürütülemeyeceğini söylerken (P3), başka bir okul müdürü müziksiz, resimsiz ve fiziksel aktiviteler olmayan bir hayatın düşünülemeyeceğini bu yüzden de STEM eğitimine sanat ve beşeri bilimleri katılması gerektiğini vurgulamıştır (P7).

STEM eğitiminin ülkeye katkısıyla ilgili yapılan yorumlarda müdürlerden biri her düşüncenin düşünme aşamasında iyi olduğunu ancak uygulamaya geçtiğinde sonuçların incelenmesi gerektiğini vurgulamış ve STEM eğitiminin eğer verimli, sonuçlar veriyorsa uygulanması gerektiğini belirtmiştir (P5). Bir diğer okul müdürü STEM eğitiminin çıkış amacı da olan, STEM eğitiminin ülkelere ekonomik katkılarından bahsetmiş ve STEM eğitiminin bir ticaret aracı olarak ülkeye geri dönüş sağlayacak şekilde girişimcilik ruhu etrafında geliştirilmesi gerektiğini söylemiştir (P10). Bu sayede STEM eğitimi ile amaçlanan katkının sağlanabileceğini vurgulamıştır.

Katkılarının yanında okul müdürleri STEM eğitiminin politika olarak eksik bıraktığı alanlardan da söz etmişlerdir. Bazı okul yöneticileri tarafından vurgulandığı üzere, ülkelerin kültür, ekonomik ve sosyal yapılarının farklılığından kaynaklı olarak her eğitim yaklaşımı her ülke ve her eğitim sistemi için uygun değildir. Amerika Birleşik Devletleri'nin eğitimdeki ve ekonomideki ihtiyaç ve istekleri ile ülkemizdeki eğitim ihtiyaç ve istekleri birbirinden farklı olduğundan STEM eğitimi tek başına bir cankurtaran simidi olarak görülmemelidir (P1, P3, P10). Ayrıca bir okul müdürü ülkemizdeki eğitim programıyla öğretimi yapılan matematik ve fen bilimleri derslerinin STEM eğitimi yoluyla daha iyi öğretilmeyeceğini vurgulamıştır (P3). Buna ek olarak STEM eğitimi ile ülkemizdeki eğitim sistemi uyumsuzluk göstermektedir. Bunun nedenlerinden biri okul müdürleri tarafından üniversite giriş sınavlarına hazırlık süreci olarak belirtilmiştir. Ek olarak okulların açılış kapanış saatlerinin belli olması ve öğrencilerin okullara uzak noktalardan gelmelerinden dolayı STEM eğitiminin uygulanamayacağını belirten bir okul müdürü olmuştur. Çünkü STEM eğitimi esnek çalışma saatleri, girişimcilik ruhu ve istek gerektirmektedir. Burada okul müdürü tarafından verilen örnek Steve Jobs'ın evinin garajında geceleri çalışarak kurduğu Apple şirketi ve bu şirketin şu anda dünyadaki başarısıdır ve okul müdürünün söylediği üzere Apple'ın gece garajda çalışılarak kurulduğu düşünülürse STEM eğitimi sınıf ortamında ders sırasında uygulanabilecek bir eğitim yaklaşımı olarak

düşünülmelidir (P10). Tüm bunlara ek olarak okul müdürlerine göre STEM eğitiminin nasıl uygulanacağına dair bilgi eksiklikleri ve altyapı yetersizliği STEM eğitiminin uygulanması konusundaki diğer engellerdir.

İkinci araştırma sorusunun temalarından ilki olan okulların durumuyla ilgili iki alt temadan söz edilebilir. İlki görüşme yapılan okul müdürlerinin çalıştıkları okullardaki öğrencilerin niteliğidir. Tüm okul müdürleri okullarında bulunan öğrencilerin STEM eğitimi uygulamalarında yer alabilecek düzeyde ve nitelikte olduğunu belirtirken, bazı okul müdürleri öğrencilerin meraklı ve öğrenmeye açık olduğunu da sözlerine eklemişlerdir. Bir diğer alt tema ise öğretmenlerin STEM eğitiminin uygulanması konusundaki deneyim, bilgi ve becerileri ile ilgilidir. Tüm okul müdürleri STEM eğitimi ile ilgili öğretmenlere hizmet içi eğitim verilmesi gerektiğini dile getirmişlerdir. Bunun yanında STEM eğitiminin öğretmenlerin fedakârlıkları ile gerçekleştirilebileceğini çünkü esnek çalışma saatleri gerektiren bir eğitim yaklaşımı olduğunu vurgulayan bir okul müdürü olmuştur (P10). Ayrıca her öğretmenin yeni yaklaşımlar deneme konusunda istekli olmadığını ve bazılarının geleneksel eğitim öğretim yönteminden vazgeçmeyeceklerini de vurgulayan okul müdürleri bulunmaktadır.

Görüşme yapılan okul müdürlerinin çalıştığı liselerde STEM eğitimi konusundaki deneyimler kısıtlıdır. Okulların öğrenci ve öğretmen ile ilgili durumlarının yanında okuldaki altyapı eksiklikleri okul müdürleri, tarafından bu konuda belirtilen bir diğer engeldir. Tüm bunlara rağmen STEM eğitimi deneyimi olarak görülen ve tüm okul müdürleri tarafından belirtilen yegâne etkinlik TÜBİTAK proje yarışmalarıdır. Çok çeşitli branşta hazırlanabilen bu projeler, matematik, fen bilimleri, kodlama gibi alanları da içinde barındıran etkinliklerdir. Ancak bu etkinlikler tüm okul öğrencilerinin katılımıyla değil, bireysel ya da küçük gruplar halinde çalışan öğrencilerin katılımıyla gerçekleşmektedir.

Son araştırma sorusu ile ilgili ortaya üç tema çıkmıştır. Bunlardan ilki okul müdürlerinin okuldaki süreçlere yardımcı olma rolleridir. Okul müdürlerinden biri bu durumu okulda hem hizmetli hem de müdür olarak çalıştıklarını, öğrencilerin ve öğretmenlerin ihtiyaçları doğrultusunda hareket ettiklerini söyleyerek açıklamıştır (P8).

Okul müdürlerinin belirtilen bir diğer rolü ise destekleyici olma rolüdür. Yeni fikirler ve proje önerileriyle gelen öğretmen ve öğrencilerin desteklendiğinden bahsetmişlerdir. Ayrıca motivasyonu sağlama rollerinin olduğunu söyleyen bir okul müdürü de olmuştur.

Motivasyon sağlayıcı rolleriyle müdürler okuldaki fikirleri desteklediklerini ve okul gelişimi ile öğretmen eğitimlerine önem verdiklerini vurgulamışlardır. Müdürlerin bu rolüyle ilgili açık kapı politikası benimsediğini ve üzerine düşünülmüş her fikrin desteklendiğini söyleyen bir okul müdürünün (P9) yanında öğretmenleri okulun misyonunu gerçekleştirmede ve vizyonuna ulaşmada lider olarak yönlendirdiğini ve bu konuda motivasyon sağladığını söyleyen bir okul müdürü de vardır (P7).

Tartışma

Bu çalışmanın amacı STEM eğitiminin etkililiğini ölçmek değil, okul yöneticilerinin STEM eğitimini nasıl algıladıklarını anlamaktır. STEM eğitimi alanyazında ve eğitim politikası raporlarında iddia edildiği üzere öğrenme ortamına ve öğrencilerin 21. yüzyıl becerilerini kazanmalarına katkı sağlayacak bir eğitim yaklaşımı olabilir. Ancak bu çalışmanın sonuçlarının gösterdiği üzere STEM eğitiminin uygulanması için hazırbulunuşluk ve bilgi düzeyinde yetersizlikler bulunmaktadır. Bilgi eksikliğinin bulunduğu bir konuda öğrencilerin öğrenimleri üzerine olumlu katkı sağlanılması güçtür. Okul müdürlerinden birinin bahsettiği üzere yeterli donanım, altyapı ve bilgi birikimi olmadan uygulanmaya kalkılırsa STEM eğitimi sadece öğretmen anlatımına (lecturing) dayanan yeni bir ders adı olmaktan öteye geçmeyecektir (P10).

STEM eğitimiyle ilgili ilk sorun Türk eğitim sistemi ile STEM eğitimi arasındaki uyumsuzluktur. Amerika Birleşik Devletleri'nde ortaya çıkan STEM eğitiminin ortaya çıkış amacı STEM alanlarında kariyer yapmak isteyen ABD doğumlu birey sayısını arttırmak ve onları ekonomiye kazandırmaktır (Land, 2013). Türkiye'nin mühendislik ve fen bilimleri alanlarındaki mezun sayıları (YÖK, 2017; YÖK, 2018, YÖK, 2019) ve iş bulma durumları düşünüldüğünde iki ülke arasında farklılıklar olduğu gözlemlenmektedir. Bu yüzden Türkiye'nin ihtiyacı olan şey üniversite düzeyinde daha çok insanın mühendislik ve fen bilimleri alanlarında eğitim alarak bu alanlardan mezun olması değil, mevcut mezunların beyin göçünün engellenerek ülke ekonomisine kazandırılmasını sağlamaktır. Bu nedenle STEM eğitiminin eğitim

sistemi ile uyumsuzluğu ve uygulamadaki eksiklikler, bu kavramın bir politika ithali sorunu olarak karşımıza çıkmasına neden olmaktadır.

İkinci olarak STEM eğitiminin ülkemizde uygulanması için gerekli altyapı tüm okullarda mevcut değildir ve bu da STEM eğitiminin bir eğitimde eşitlik sorunu haline getirmektedir. Özel okulların STEM eğitimini bir reklam aracı olarak kullanması ve bu konu ile ilgili eğitim programları hazırlamasının yanında devlet okullarının altyapının geliştirilmesi için ulaştıkları fırsatlar birbirinden farklıdır. YEĞİTEK (2018) raporunda STEM eğitimi için pahalı altyapılara gerek duyulmadığı ve STEM eğitiminin zaten okullarda var olduğu belirtilirken okul müdürleri bu konuda aynı görüşte değildir. Üç boyutlu yazıcılar, pahalı bilgisayar programları ile yüksek işlemcili bilgisayarların STEM eğitimi için gerekli olduğunu ve çoğunlukla bunu karşılayamadıklarını vurgulamışlardır. Tüm bunlar düşünüldüğünde genel bir altyapı eksikliği sorunundan söz etmek mümkündür.

Altyapı eksikliğinin yanında, okullarda uygulayıcı eksikliği de bulunmaktadır. Bunun nedeni, bu çalışmada ortaya çıktığı üzere okul müdürlerinin ve alanyazında belirtildiği üzere öğretmenlerin bu konuda mesleki gelişime ihtiyaç duymalarıdır (AlKhateeb, 2018; Bartholomew, 2017; Chai, 2019; Havice vd., 2018). Öğretmenler mesleki gelişime ihtiyaç duymaktadır ancak öğretmenleri STEM eğitimi gibi disiplinler arası bir yaklaşımla ilgili bilgilendirecek eğitimci ihtiyacı da göz ardı edilmemelidir. Çünkü bu konuda insan kaynağı eksikliği mevcuttur (Chai, 2019).

Okulun öğretim liderliği rolünü de üstlenen okul müdürlerinin STEM eğitimi hakkındaki bilgi ve algı eksikliği bu çalışmayla ortaya çıkmıştır. Bu durumda sadece öğretmenlerin kendilerini STEM eğitiminin gerektirdiği disiplinler arası yaklaşımla donatmalarını istemek haksızlıktır. Bu yüzden STEM eğitiminin uygulanmasına olanak sağlayacak bir okul kültürü oluşturmak gerekmektedir (Kondakçı & Kulakoğlu, 2018). Bu tür bir okul kültürünün oluşturulması için, normlar, değerler, felsefe ve vizyon bakımından örgütsel bir değişim gerekmektedir (Lunenberg & Ornstein, 2004). Ancak müdürlerin belirttiği üzere, okulların misyon, vizyon ve amaçlar bakımından Milli Eğitim Bakanlığı'na bağlılıkları düşünüldüğünden değişimin üst yönetimden alt yönetimlere doğru yapılması gerektiği ortaya çıkmaktadır. Tüm eksik ve engeller göz önünde bulundurulduğunda konuyla ilgili

politika ithali, altyapı, insan kaynakları bağlamlarında düşünülmesi gerekenler vardır. Bu yüzden, STEM eğitimi ile ilgili uygulamalar için daha zaman vardır ve program geliştirilmesi için daha fazla çaba gerekmektedir (Kanadlı, 2019).

Son olarak STEM eğitimi ülkemizde tam anlamıyla uygulanan ve somut uygulama örnekleri olan bir eğitim yaklaşımı değildir. Türkiye'deki eğitim programları ve öğretim teknikleri düşünüldüğünde STEM eğitiminin disiplinler arası yaklaşımla öğretimi gerektiren doğasıyla uyumluluk göstermemektedir. Bunun nedeni öğretmen ve öğretmen adaylarının disiplinler arası bir yaklaşıma dayalı öğretimle ilgili olarak yetiştirilmemesi ve bu konuda dünyada olduğu gibi Türkiye'de de insan kaynağı eksiği olmasıdır (Chai, 2019).

Bu çalışma, okul yöneticilerinden toplanan verilerden elde edilen sonuçlara göre, hazırbulunuşluk, bilgi ve altyapı eksikliklerinin okullarda STEM eğitiminin uygulanmasında engel teşkil ettiğini göstermektedir. STEM eğitiminin tam olarak anlaşılmadığı ve bu konuda bilgi eksiklikleri olduğu bir gerçektir. Ayrıca okulların fiziksel altyapı açısından geliştirilmesi gerekmektedir. Bir uygulamanın yapılabilmesi için tek gereken materyal eksiklerinin giderilmesi değildir. En önemli nokta konu hakkında bilgi sahibi olan uygulayıcıların olmasıdır. STEM eğitiminde bahsedilen uygulayıcılar öğretmenlerdir. Ancak okullarda yürütülen eğitim öğretim süreçlerinde yapılacak değişiklikler ve yeni uygulamalar okul yöneticilerinin bilgisi ve destekleri sonucunda bir yere varabilmektedir. Bu yüzden, öğretmenlerin olduğu kadar okul yöneticilerinin de STEM eğitimi hakkında bilgi sahibi olmaları ve bu konunun okullarda etkili bir şekilde uygulanması için süreç yönetimi ve öğretim liderliği rollerini üstlenmeleri gerekmektedir. Tüm bunlara rağmen okullardaki eğitim öğretimden sorumlu insan kaynağını, disiplinler arası bir yaklaşımla yetiştirecek ve geliştirecek eğitimci eksikliği mevcuttur (Chai, 2019). Tüm bu eksik ve engellere rağmen STEM eğitiminin eğitim sistemimize uygulanmasında ısrarcı olmak doğru değildir. Bu tip bir politika ithali ile olmazı oldurmaya çalışmaktansa mevcut eğitim sisteminin iyileştirilmesi ve geliştirilmesi için çalışmak daha akıllıca olacaktır. Okullarda yürütülen fen bilimleri, matematik ve bilişim teknolojileri derslerinin geliştirilmesi ve daha iyi eğitim öğretim ortamları hazırlanması için çalışılması gerekmektedir. Her sene olduğu gibi bu sene de ÖSYM (2019) tarafından yayımlanan istatistiklere göre üniversite sınavının ilk ayağı olan TYT'de (Temel Yeterlilik Testi)

temel matematik alanındaki ortalama 40 soru üzerinden 6,08 iken fen bilimleri testinde ortalama 40 üzerinden 2,70 tir. Bu ortalamalar göz önünde bulundurulduğunda okul kültürünün değişmesini gerektiren bir eğitim hareketi olan STEM eğitimini okullarda uygulamaya çalışmak yerine matematik ve fen bilimleri derslerinde başarıyı arttırmak için eğitim öğretim ortamlarındaki uygulamaları iyileştirmeye ve geliştirmeye çalışmak daha iyi olacaktır.

Araştırmanın sonuçları STEM eğitimi ile ilgili okul yöneticilerinin bilgi eksikliği olduğu kadar bu konuda okulun eğitim öğretim süreçlerinin temeli olan öğretmenlerin de bu uygulamaları yapmak için hazır olmadıkları, altyapıda yetersizlikler olduğu ve okullardaki geleneksel eğitim öğretim süreçlerinin STEM eğitimi ile uyumluluk göstermediği görülmüştür. Bu yüzden yapılması gereken Milli Eğitim Bakanlığı, üniversite, okul ve politika geliştiricilerin ortak çalışması ile eğitim sistemimizde gereken iyileşmeyi ve gelişmeyi sağlamaktır. Her ülkenin kendine özgü kültürü, tarihi, eğitim ihtiyaçları ve sosyolojik altyapısı vardır. Bu yüzden, yapılması gereken bir politika ithaline bel bağlamak değil, kültüre, sosyolojik yapıya ve eğitim ihtiyaçlarına uygun iyileştirmelerde bulunmak ve okulların her yönden gelişimini sağlamaya çalışmaktır.

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APPENDIX F: TEZ İZİN FORMU / THESIS PERMISSION FORM

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TEZİN ADI / TITLE OF THE THESIS (**İngilizce** / English) :
The Unknown Territory of STEM: The Perceptions of High School Administrators

TEZİN TÜRÜ / DEGREE: **Yüksek Lisans** / Master ■ **Doktora** / PhD ☐

1. **Tezin tamamı dünya çapında erişime açılacaktır. /** Release the entire work immediately for access worldwide. ■
2. **Tez iki yıl süreyle erişime kapalı olacaktır.** / Secure the entire work for patent and/or proprietary purposes for a period of **two years. *** ☐
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