Ministry of National Education
General Directorate of Innovation and Educational Technologies
STEM EDUCACTION REPORT
To enhance prosperity and welfare of Turkish public, support and accelerate social and cultural development and make Turkish nation constructive, creative and outstanding member of the modern civilizations are the main goals of our education system. In many education systems all over the world, it is aimed to raise students who produce, contribute to the social and economical developments, and possess the 21st century skills. Due to the necessities of the era we are in, and technological developments the need for students who can think, inquire, make research and produce new inventions increases day by day. Therefore STEM (Science, Technology, Engineering and Mathematics) education which enables students to think of the information they gain in science, technology, engineering and mathematics as a part of a whole has been started to be included in educational curricula of many countries. The aim of STEM education is to convert theoretical information into applications, products and innovative inventions.

Interactive whiteboards provided for schools, broadband internet infrastructure, tablet computers provided for teachers and students, electronic content provided by EBA are informatics technologies that students can use to improve their questioning, researching, product creating and inventing skills. Furthermore, Fatih Project will meet students’ needs related to benefiting from information technology and scientific developments equally and reaching to equal opportunities. Raising individuals who can keep up with the era, possessing 21st century skills, thinking and questioning, developing products and who are innovative are among the educational goals of our national education system. Therefore we think that it is important that the integration of STEM education which aims for a qualified and productive society and serve for it into our education system by benefiting from advantages of the innovative education environment constructed by FATIH Project and EBA and innovation and transformation trend.

I would like to point out that this report ready for development and deepening is open to any ideas and suggestions of related bodies of the Ministry and shareholders. I hope that this report will be brought in during the ongoing renewal studies of the education curriculum and it will be a reference for these studies.

I appreciate the great works and efforts of staff of Ministry who contributed greatly to the STEM Education Report which is prepared for the purpose of developing our dynamic education system which is being renewed everyday according to the educational needs of our time and raising a generation who will invent scientifically in the future.

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Minister of National Education
Since STEM education for students have been started for sustaining the economic developments in the world, Starting to the integration of STEM education into our education system is important. This report has been prepared by reviewing present literature and taking into consideration of the opinions of specialists, academicians and STEM teachers by a team of teachers who work in Ministry of National Education, General Directorate of Innovation and Education Technologies and have academic background on STEM education.

In this report, STEM education is described then how it first arouse and its goals are explained. Also, studies related to STEM education done abroad especially in United States of America and European Countries are examined and the status of STEM education in Turkey are shown.

Also topics such as model recommendations for the transition to STEM education in Turkey, establishing STEM centers, conducting STEM researches, training teachers according to STEM approach, updating curricula according to STEM, creating suitable environments in schools for STEM, providing necessary materials are highlighted in the report. Moreover, results of the research which is conducted by General Directorate of Innovation and Education Technologies to identify teachers' opinions on STEM education are announced.

In the evaluation part of this report, recommended actions to be done for the integration of STEM education into our education system and a STEM Education Action Plan as a recommendation are presented. This report is open to any comments and recommendations from any ministry bodies and share-holders. This report also aims to contribute to the updating of the STEM curriculum.
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INTRODUCTION

People have always had the desire to learn more and achieve greater life skills. In 21st century, it has become easier to gather information and as a result, information age has arisen with the developing technology. Today’s world expects people to be productive. In order for individuals to be productive, new and different programs need to be applied to encourage people to question, think and create more (Akgündüz et.al., 2015). Therefore education system needs to transform accordingly (Çakıroğlu, 2016). In 21st century, the competition in technological development has been accelerated. Also China has become a rival in terms of economy, technology and industry after United States of America (USA) and Japan became rivals in 1980’s. This led developed countries into investing in science, engineering and innovation. United States of America has started several reforms for this purpose. The most popular of them is a curriculum which leads schools and states about which objectives to teach and how to teach these objectives in science education, which was published in National Science Education Standards in 1996 (National Research Council., 1996, akt. Akgündüz et.al., 2015). This program got credit in both United States of America and many developing and developed countries. The aim of this program is to enable every student experience learning in classrooms.

European Union (EU) published a report named "Science Education Now: A New Pedagogy for the Future of Europe" in 2007 (Rocard at all., 2007, akt. Akgündüz et.al, 2015). In this report, Europe’s science and technology issues were highlighted and stated that students' interest in science, technology and mathematics drastically decreased (Akgündüz, et. al, 2015). Report suggested that science education should be based on inquiry, the cooperation between shareholders in science education should be provided and improving communication network of teachers for enhancing motivation is needed.

In USA and the member states of European Union, many programs and projects were started for the reason of creating educational approaches which provide attainment of skills, preparing students for life, putting importance on the necessities and skills of modern business life (Akgündüz, et al, 2015). The latest program among them is STEM education and its applications (Gülhan & Şahin, 2016). STEM education means integrated Science, Technology, Engineering and Mathematics education.

FeTeMM which is the Turkish abbreviation of STEM (Science, Technology, Engineering and Mathematics) education helps students enrich their cultural perspectives, gain critical thinking and improve skills such as problem solving (Çorlu & Aydın, 2016). Students needs to adapt to these skills when they enter the business world. STEM education has been brought in because it can meet these necessities and approach problems with a holistic perspective (Bybee, 2011).
What is STEM education?

STEM education aims to help students solve problems with a multidisciplinary perspective and gain knowledge and skills in a holistic perspective. (Şahin, Ayar, & Adıgüzel, 2014). STEM education is an interdisciplinary approach which covers the whole process from kindergarten to higher education (Gonzalez & Kuenzi, 2012).

For example, according to Lederman and Niess (1997) interdisciplinary approach means an undivided whole and it looks like the compound in chemistry. These compounds have different features than the elements they are made up of. Similarly disciplines create a clearer and much different image when they are integrated (Lederman & Niess, 1997). STEM education can be considered as an education covering high quality learning combining disciplines, making use of current information in daily life, increasing life skills and superior and critical thinking (Yıldırım and Altun, 2015). STEM education encourages students for the direct learning (Çakiroğlu, 2016). For instance students can produce what they design mentally and use what they learn in different problems (Özdemir, 2016). Works related to STEM education shows the importance of STEM education for the reason of transforming theoretical knowledge of Science, Technology, Engineering and Mathematics into application and products (Çorlu, 2013 Erdoğan, 2013). Today is a time where technology based education is inevitable. Therefore individuals are expected to be productive and inventive. This foresees that individuals need to combine Science, Technology, Engineering and Mathematics to be able to show their productivity (Akgündüz, et. al, 2015). Also the fact that STEM education has an infrastructure highlighting an technological and engineering approach and provides children an interdisciplinary approach puts STEM in a very important place in today's information and communication era (Akgündüz, et.al, 2015). STEM education is an education approach which helps students gain creative problem solving skills (Roberts, 2012).
Supporters of STEM education think that course subjects which involve real world problems will increase students' interest, success and motivation. As a result of this number of the students who have a career in sciences will increase (Honey, Pearson, & Schweingruber, 2014). STEM is an education which supports the mental development, entrepreneurship and product development. Similarly the base of scientific skills is also to produce, initiate and invent. Entrepreneurship means that people take initiative to make their dreams come true and act accordingly. Entrepreneurship is a process of taking risk and acting and it also provides awareness and production skills. Philosophy of informatics states that productive people need to have self respect first. That's why production is important for fulfilling students' curiosity in classrooms because production enables self respect. Lastly, self respect leads to confidence (Özdemir, 2016).
STEM education has aims such as directing students' energy and interest in a way that they can serve for public, face problems and issues encouraging for learning and create opportunities for being in different environments. Another aim of STEM education is to remove the gap between these disciplines, create a full integration among them (Wang, 2012) and raise a generation with inquiry, production and invention skills from kindergarten to university. Also, STEM education aims to identify students curiosity and inquiry skills in primary and secondary schools and direct and encourage these students to Science, Technology, Engineering and Mathematics departments of universities generally.

Another aim of STEM education is to remove the gap between disciplines, creating a full integration (Wang, 2012) and raising a generation with inquiry skills, productive and inventive from kindergarten to university.

Today is a time where technology based education is inevitable. Therefore individuals are expected to be productive and inventive. This foresees that individuals need to combine their Science, Technology, Engineering and Mathematics (STEM) knowledge to be able to show their productivity and invention skills.

In addition to the above mentioned statements, Morrison stated that providing logical thinking with STEM education increases students' confidence and help them adopt the main principles of technology (Morrison, 2006). Students combine science and nature of science with the knowledge they achieved (Yıldırım and Altun, 2015). STEM education improves planning, critical thinking and evaluation skills as well as problem solving. STEM education follows constructivist and student centered education. That's why STEM education is very important in terms of implementing theoretical information and transforming this information into inventions. STEM education also enables development of empirical approach, learning by doing, inquiry, research and inventing which are important for the increasing workforce quality in the world. And this will serve for production, research and development, innovation and development of technical infrastructure and closing the gap in qualified workforce (TUSIAD, 2014).
STEM education focuses on universal literacy skills. These skills are creative thinking, critical thinking, problem solving and collaborative learning. Students need to achieve these skills. In this context, teachers' role is helping students reach the level of higher order thinking, product development, invention and innovation by leading but not teaching theoretical content knowledge on Science, Technology, Engineering and Mathematics to them. It is important to create a learning environment where students aren't afraid of failing and are confident. To summarize, there isn't only one outcome expected from STEM education. Teacher should encourage the students when they fail and also encourage them to do better when they achieve the expected outcome and provide them necessary opportunities. In this way, students will gain the philosophy that innovation never ends (Özdemir, 2016).

STEM education has become a necessity for all countries. Developed countries give up content based education system arouse after industrial revolution and they aim to base their education system on STEM education. The reason for this is that information technology age needs cognitive processes and productions skills more than labor and muscle force.
Recently an approach called STEAM education which means the inclusion of Art education into STEM is being discussed (Yıldırım and Altun, 2015). According to Özdemir (2016), STEM education is an ever improving field. There are a lot of different views on this topic. One of these views is about two important misconceptions about STEM education. First one is that the letter "E" in STEM doesn't only mean "Engineering" but also means "design and production". Second one is that letter "S" meaning "Science" includes also "humanity and social sciences". Also, there are abbreviations such as ESTEM, STEAM and S-TEAM instead of STEM. The letter "A" in these abbreviation means "Art" which cover esthetics as well. "E" letter in ESTEM means entrepreneurship.

Fared Zakeria which is an author in USA stated that the art and social sciences education is very important and without them STEM education won't be a whole (Özdemir, 2016). According to Özdemir (2016), STEM education is a must for all countries. Developed countries aim to base their education systems on STEM education by giving up the education systems brought by industrial revolution. The reason for this is mental processes and production skills are more important than labor and muscle force in the information society. For example, the fact that there are 3D productions and remote controlled planes (drones) usage in cargo industry in Europe and America support his argument.
STEM Education Strategies of Countries

STEM education and STEM workforce are at a more important status in many countries which aim to develop in technology and innovation. Today, many countries include STEM education into their education systems. STEM has been used in primary schools, secondary schools and universities in leading countries such as United States of America, European Union member countries, Japan, Korea, Germany and China. Recent researches show that STEM education in primary and secondary schools reaches its highest level in universities. It could be deducted that STEM education contribute greatly to the students’ choice of profession (Gonzalez and Kuenzi, 2012). STEM education approaches of several countries have been given below:

**United States of America (USA)**

STEM education is seen as one of the most important elements in maintaining the present economical and technological status in The United States of America. One of the points on which the country insists on is to create a skilled society with STEM education and maintain this society. Therefore a great number of STEM Centers have been established within many universities and schools. Many elements such as project-based learning, inquiry-based learning, STEM activities, design and innovation activities, team work, creativity and creative drama, robotics, maker, coding and STEM course plan preparation workshops are included in these centers (STEM Akademi, 2013). In STEM schools in which plotting are launched, students produce the products they have designed in workshop studies in the classrooms. These students are expected to produce with the help of technology and produce high quality products (Özdemir, 2016).
USA has started several curriculum reforms related to education. The most popular one is a curriculum published in 1996, which leads states and schools about how and what to teach in science courses (National Research Council - NRC, 1996). The aim of this curriculum program is to help students develop inquiry-based learning skills. STEM education is implemented in two ways in USA: Integration of engineering skills as an interim discipline in curriculum and establishing STEM schools for successful students (Akgündüz, et. al, 2015).
Common feature of STEM schools is that they are the schools in which innovative pedagogies such as project-based learning and engineering design process are implemented. These pedagogical innovations established for the reason of helping students get employed in STEM fields aim to develop students' critical thinking skills. Also it is aimed that information and skills required by American business world will be gained.

STEM schools which accept students without any exam results or criteria become prominent in USA. These schools aim to increase STEM motivation of students from all socioeconomic status. Also these schools aim to encourage students with low socioeconomic status to universities (Akgündüz, et.al, 2015).
China has given great importance in science education and stated that science is the main block for a developed society for many years. Science teaching in the Chinese education system has a specific characteristic. Biology, Chemistry, Mathematics in which STEM education is integrated are compulsory subjects on high school level. STEM education has been developed in the higher education and trend in STEM subjects has increased in the last 6 years. Curriculum for 10th-12th grades have been updated. STEM subjects have been integrated into teacher training programs (Gao, 2015).

Russia has focused on reinforcing higher education institutions within the national education strategy. They also have focused on completing the missing points with new curriculum programs. Government has published three initiative items for STEM education:

1. Enhancing the quality of engineering programs,
2. Improving mathematics education,
3. Developing engineering, medicine and science education programs of higher education institutions with the leadership of universities (Smolentseva, 2015).
European Countries

According to STEM education report prepared by Kearney (2015), European countries has given importance to STEM education and implemented it as followings:

Norway has adopted STEM as a priority. As of 2002, Norway prepared a strategy plan called “STEM of course”. This plan has four goals:

1. Improving students skills within STEM education and updating STEM subjects, providing better learning, enhancing motivation,
2. Decreasing the number of students who have low level of skills in mathematics,
3. Increasing the number of students who have high level of skills in STEM,
4. Increasing STEM teaching skills of all teachers from kindergarten to secondary school.

Actions taken for this purpose is updating the framework plan created for kindergarten, primary school and secondary school according to STEM subjects and tasks, reassessing and simplifying Mathematics subjects and improving course activities.

Netherlands has a specific STEM strategic plan. According to the plan prepared between 2004-2010, change in science and technology education is aimed for increasing the number of skills of those who can innovate in future. This action plan aims to increase the number of scientists and engineers and also increasing the interest in these subjects.

France prepared a strategy plan in 2011. The aim of this plan is to include science and technology in curriculum in a more effective way. In the action plan prepared by The Ministry of Education of France, teachers' trainings related to science projects and usage of experimenting tools are aimed to be developed with contests and fairs. Besides, new curriculum has been prepared for primary and secondary schools.

Malta published a strategic plan in 2011. A working group of three education sector (public universities, private universities and church universities) was created. While updating secondary school science teaching curriculum programs, Malta focused on detecting students with low skills and planned to increase skills of these students. These students can choose the desired science branch. Within this plan the followings are aimed:

1. Analyzing different science education programs and researches,
2. Changing pedagogical processes in science education,
3. Focusing on learning outcomes in curriculum programs.

Also, TIMMS and PISA test results are included in the strategy plan.
Croatia designated a new strategy on education, science and technology in 2014. The aim of this strategy is to enable every individual in society to examine and follow equally the developments related to education and technology. It was based on life-long learning concept. Also this strategy aims to create new opportunities and contribute to industrial leadership, high quality education, creativity and socio-economical success. This strategy aims to increase competition by making STEM education more interesting. This is expected to contribute to economy.

Lithuania doesn't only focus on STEM but also focuses on creating a new strategy which will cover STEAM education. The action plan to be put into practice between 2015-2020 covers the cooperation of business, industry, research and education experts. This plan provides a systematical approach to education processes in Science, Mathematics, Technology and Art activities. One of the goals of the plan is to conduct creative and innovative works so that students can be more interested in STEAM. Also this plan aims to increase teachers' proficiencies and popularity of STEAM education.

England published a report covering between the years 2004-2014 for the purpose of what has been achieved in Science, Technology, Engineering and Mathematics education in 2004. This report examined the approach to STEM education. Between 1999-2011, a national strategy has been developed for the improvement of primary and secondary school curriculum in England. In the process of development of curriculum program average level of science have also been included into curriculum. At the end of this strategy, schools which implement school-focused self developing education system have been seen to be in a better situation in terms of STEM education.

Scotland published important and necessary changes in curriculum with a report in 2003. According to the report, curriculum needs to be rearranged in a way that it should be developed with innovative, inquiry and research based course activities and be suitable for educating students who are willing to learn instead of being teacher centered and content based activities. This report claims that there is a deficiency in number of scientists, amount of technical support and scientific infrastructure. According to the recommendations in the report, there needs to be course activities encouraging students interested in science. Technical assistance should be improved for teachers and professional development of them should be supported.

Ireland focuses on STEM skills in the report published in August, 2010. The report consists of 4 main headings and 20 recommendations. First heading highlights that there is a need for business world to be leading for the development of STEM education. Second heading is about decreasing or lifting the limitations of STEM education. Other last two headings are increasing the flexibility in STEM education and government support for STEM education studies.
**Israel** gives priority to STEM education on national level. Israel focus on developing high technologies with education and give importance to STEM education on professional trainings. The reforms related to STEM education aim to provide coordination between teachers, unions and Ministry of Education and to increase the activities for STEM education by means of research and development of the education system.

**Bulgaria** prioritize STEM education. However several strategies have been developed instead of only one. Several strategies prepared between 2013-2014 to support education, research, technological development and innovation for serving for economical growth. Each of the strategies have been considered for a different kind of STEM education. These strategies have been considered to contribute to the solutions of educational problems.

**Switzerland** has announced the general educational aims and results of the political actions for the education system in 2015 strategy plan. It was also stated in the 2015 Strategy Plan that STEM related occupations and career stages need to be strengthen and adapted to all education levels. STEM education attempts to cover the coordination between regions and increase in STEM education activities. Regions of Switzerland have already created their own STEM education strategies and determined their priorities.

**Czech Republic** A general strategical document is prepared. It is focused on the general education policy of the Czech Republic. STEM education is focused on covering subjects such as basic technological skills, mathematics and science literacy and informatics technologies. Aims of this strategy study is to draw public's attention into technical education, systematical changes, sharing experiences and increasing cooperation.

**Estonia** describes STEM education as an important part of life long learning between 2014-2020. Strategic plan focuses on basic skills, cross curricular skills and general skills and supports the changes in curriculum for reaching success. Life Long Learning Strategy and STEM education are inter-related. STEM education involves providing students with high level of basic skills, usage of digital equipments for improving student success and digitally supported schools which are accepted as research schools.

**Greece** is one of the countries which implements STEM education. It covers topics such as updating Greek education system, enhancing quality, planning STEM education actions, teaching science by experimenting in schools.
Spain hasn't got a STEM education strategy to a great deal. However it stated the necessity of STEM education in LOMCE, a law covering education quality. This law involves topics such as increasing skills of students with teaching Science and improving students' levels in Mathematics and Science PISA tests.

Finland has the broadest national plan for STEM education. The report which was published in 2014, creation of working groups are supported to increase the students' interest and skills in STEM education. These groups are expected to act as cultural and educational leaders. Moreover, related institutions, universities and other organizations have their own STEM education strategies.

Romania included STEM education into their national education strategy. Importance of STEM education is highlighted for the development of the industry.

Latvia has a strategic plan for STEM education. One of the goals of the plan is to increase students' proficiency in mathematics and science. To achieve this goal, it is aimed to use digital learning tools for the development of research skills and creativity of primary and secondary school students with STEM learning activities.

Poland's Ministry of National Education has given importance in STEM education. They firstly updated the curriculum for a higher quality secondary school education in 2014-2015 and focused on improving mathematics skills. As a result, developments in mathematics and science education have been observed at the end of 2015-2016 education term.

Italy is aware of the importance of STEM education although it doesn't have a specific STEM education strategy.
Although Turkey doesn't have a direct STEM action plan prepared by the Ministry of National Education, there are some strategical goals appropriate for the strengthening the STEM education in the 2015-2019 Strategic Plan. These STEM related goals match up with the outcomes of Technology and Design courses. It can be said that more studies should be done on 7th and 8th grade Technology and Design courses that include STEM. It is important to discuss STEM education as a priority for the students so that the results of exams such as TIMSS and PISA can be improved.

Besides, it was found by Turkish Industry and Business Association (TÜSİAD) that the employment rate of people who graduated from STEM education department of universities is 19% (TÜSİAD, 2014). After examining the data from Measuring, Selection and Placement Center for universities (ÖSYM) it was seen that the rate of graduation from STEM departments is 19% (OSYM, 2014). When analyzing which field they contribute to in companies it was seen that there is a significant difference between those who work in STEM related occupations and those who work outside STEM (TÜSİAD, 2014). TÜSİAD (2014) highlights that STEM education is important for the country and a STEM education strategy should be set immediately. The priority of this strategy should be increasing the number of students who will be educated in STEM and creating employment activities in this respect. Also investment in research & development should be supported for the innovation works to be conducted. For educational respect, students are expected to reach a higher quality education and gain 21st century skills with STEM education (TÜSİAD, 2014).
2011-2016 Science Technology Development Plan of The Scientific and Technological Research Council of Turkey (TÜBİTAK) includes some activities supporting STEM education (Baran, Canbazoğlu, Bilici, & Mesutoğlu, 2015). According to this strategy, science education should be reinforced with science fairs for primary and secondary schools, activities in space science, mathematics, science and technology for older students. TÜBİTAK organizes projects and contests to identify successful students and teachers in STEM. Also, science centers have been launched in several cities by TÜBİTAK. These centers aim to help students like science and scientists, get rid of the bias in science and society.

There aren't many universities in Turkey which study and launch projects in STEM education (Çorlu, 2013). Trainings for enhancing the STEM education skills and general skills of teachers and candidate teachers in both faculties and in-service trainings aren't sufficient.

There aren't many universities in Turkey which study and launch projects in STEM education. Trainings for enhancing STEM education skills and general skills of teachers and candidate teachers in both faculties and in-service trainings aren't sufficient. For the transition to STEM education in Turkey, a number of universities have launched STEM centers accessible to teachers and students. Hacettepe University and Istanbul University are the first universities which take the first steps.
Besides, General Directorate of Innovation and Educational Technologies participate in the Scientix Project as a national contact point. Scientix Project (The community for science education in Europe), which is conducted by European Schoolnet that is founded by European Commission, started in December 2009. The website “http://www.scientix.eu/” of Scientix Project has been open to service since May 2010. Scientix is a community in which about 30 European countries participate for aiming the dissemination of good practices, projects and materials used in STEM education in Europe.

Scientix community is open to teachers, researchers, policy makers, families and anyone who is interested in STEM education. Scientix projects has been carried out as Scientix 2 between 2013 and March 2016. Third phase of the project named as Scientix 3 was started at April 2016.

The main goals of Scientix Project are;
- Informing all Europe about projects related to STEM education in Europe,
- Facilitating dissemination and sharing of materials and tools produced by STEM education projects,
- Creating a web-based platform where European national congresses, conferences, workshops or projects about STEM education could be announced to all Europe,
- Creating a web-based platform where teachers and academicians can share experiences and ideas on a European level,
- Presenting education materials suitable to inquiry-based education and adaptable to science and mathematics courses,
- Contributing to the training of STEM teachers by online and face-to-face trainings,
- Identifying students who are curious, skilled in questioning in primary and secondary schools and encouraging them Science, Technology, Engineering and Mathematics education departments of universities.

Ministry of National Education (MoNE), General Directorate of Innovation and Educational Technologies (YEĞİTEK) as Turkey National Contact Point in Scientix project, have performed some promotion activities (Scientix Fen ve Matematik Eğitimi Conference, Scientix workshops, social media online promotions, online webinars, etc.). General Directorate of Innovation and Educational Technologies as Turkey National Contact Point continues to be a partner in Scientix 3 and represented at Ministries of Education STEM Working Group coordinated by European Schoolnet.
What scientists need and what is inevitable for them is not discriminating between sciences and do well in all of them even if its not sufficient in all fields of science. Because science is beautiful and its taste is permanent. The taste is there during the research. It ends when research is done. Scientists shouldn't despise his antecedents but study their works humbly and make the most of them. Only in this way they can reach the right and solid knowledge and avoid the wrong ones.

Al-Birûni
"Science, technology and innovation" article in "innovative production, stable growth" heading of 10th Development Plan of Turkey highlight that there is a need in increase the employment in private sector (Ministry of Development, 2014). Besides, in the 64th Government Program there is a statement as "For us, it is a priority to transform in an innovative and high technological way, to reinforce our initiative capacity and create an employment infrastructure for the knowledge based economy". It can be seen that STEM education goals and the aims of 64th Government Program have the similarities (Prime Ministry, 2015).

In the present information and communication era, STEM education is very important and it needs to be implemented immediately to be able to gather necessary skills. STEM education should be launched so that students' interest in STEM can increase. And we can help them choose their profession in STEM area. STEM education will help students get ready for the life in cooperation with necessary bodies. Their success in business life will increase by using their thinking, applying and product developing skills on current issues.

STEM education will contribute to the application and transformation of technical knowledge on Science, Technology and Mathematics into products and inventions. While adapting STEM education in Turkey, it should be aimed that student will gain an interdisciplinary perspective on Science, Technology, Engineering, Art and Mathematics and also gain skills such as inquiry, conducting research, esthetical perspective and product development. Students in Turkey have energy, skills and opportunities to achieve a lot of these skills. These opportunities should be increased for them and they need to be encouraged to learn about STEM.
That's why it is necessary to prepare an action plan by the Ministry of National Education with the help of all shareholders for integration of STEM education. It is very important to plan a STEM education strategy considering the rate of young people and number of students in schools.

The cooperation between businesses and education institutions should be increased for updating the educational policies. Within the above mentioned, STEM Education Action Plan to be led by Ministry of National Education should be prepared with the steps below as shown in Figure 3:

1. Establishing STEM Education centers,
2. Conducting STEM education researches with the cooperation with universities in these centers,
3. Training teachers in a way they can adopt STEM education approach,
4. Updating curriculum in a way that it could involve STEM education,
5. Creating teaching environments for STEM education and providing course materials to schools.

According to Çakiroğlu (2016), it is important to prepare a strategy document that include national policies of the Ministry of National Education. This document should include what is STEM, what kind of benefits it will bring and how it can be matched with course subjects (whether it should be integrated into courses or provided separately). Also a single model implementation may not be suitable for Turkey. Instead of changing curriculum radically, it may be reasonable to conduct changes step by step. It will be a suitable strategy for Ministry of Science, Industry and Technology and Ministry of National Education coming together to create education policies for STEM education (Çakiroğlu, 2016). While determining a STEM education strategy, framework programs for teacher trainings should be prepared after the integration of STEM into education system for the purpose of strengthening the links between theories and application.
1. Establishing STEM Education Centers

First of all, STEM education centers should be established which are accessible to all students and teachers for the integration of STEM education into our education system. Research studies should be conducted for the integration of STEM into our education system by the coordination of these centers. These centers will be the support point for STEM education curriculum program development, teachers' in-service trainings and also for the smooth implementation of STEM education. For Turkey, there should be STEM centers at the 81 cities and their important provinces (Akgündüz, at all, 2015).

Universities are suitable educational institutions for the establishment of STEM centers. Hacettepe University took the first step and established a STEM center within their institution. Also Istanbul Aydın University created a similar center (Akgündüz, et. al, 2015). However these attempts aren't sufficient to integrate STEM education into formal education system. The best way of providing this proficiency is establishment of STEM centers by the cooperation of all faculties of education and engineering departments and working in coordination with the Main STEM center to be established under Ministry of National Education (MoNE) shown at Figure 4.

Teachers' in-service trainings and curriculum updating researches desired for STEM education can be conducted by this model. Effective coordination of universities with Ministry of National Education will be ensured and necessities for curriculum and teacher source will be met for STEM education. Also effectiveness of STEM education policies can be followed by monitoring, data collection and evaluation studies done by these centers in the education system.
Considering the data obtained from monitoring and evaluation processes, problematic points in STEM education can be resolved and necessary updates can be conducted with this evidence. In line with the data obtained by organizational structure presented in Figure 4, lacking points at teacher trainings can be identified and necessary in-service trainings can be provided to them by the nearest STEM center. Also, teachers can consult to STEM centers and participate into activities which will improve their capacity in STEM education without waiting for the in-service trainings.

In STEM centers;

1. Researches can be conducted for integration of STEM education into Turkey's education system.
2. Updated trainings such as coding as well as STEM education for teachers and students can be organized.
3. Research studies can be performed for updating curriculum programs related to STEM education.
4. Opportunities for the professional development of teachers on STEM education can be increased. Each teacher may have at least one in-service training in a year.
5. Professional teams, groups, project partnerships with other shareholders which will contribute to the professional development of teachers can be organized in these centers.
6. Projects and activities related to the STEM education product development and inventions can be conducted.
7. Contests can be organized in which teachers and students can participate for their products and inventions.

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Read content as needed, excessive content learning kills creativity. Spare time for thinking.

Aziz SANCAR
2. Conducting STEM Education Researches

After establishing STEM education centers, conducting researchers about the integration of STEM education into primary and secondary school curriculum programs, STEM teacher trainings, updating of curriculum and determining suitable course materials and tools for STEM education should be started according to teachers' and students' needs about STEM education.

Results of several studies conducted by some researchers for the integration of STEM into our education system are given below:

“The Young Inventors Design Future: Science, Technology, Engineering and Mathematics (STEM)”, a research about STEM activity done with 6th grade students (Baran, Canbazoğlu-Bılıci, & Mesutoğlu, 2015). In this activity, students were asked to design a FeTeMM spot according to the scenario given to them, which will be broadcast in television. Students designed STEM spots with storyboards. This activity showed that students improved their knowledge and skills about technology and computers in this STEM activity.
Studies done by Yıldırım & Altun (2015) highlighted the integration of STEM into course activities. This study compared STEM education with the traditional education and concluded that STEM education is effective in improving students' achievement.

The study conducted by Çorlu, Capraro & Capraro in 2014 aimed to identify STEM education. Integrated curricula and educational reforms in teaching processes and also conducted researches in and outside of Turkey have been examined. As a result of this study, it was determined that teachers who are experts in only their course subject areas can't be effective in educating students who are necessary for the future of their countries.

İstanbul Aydin University launched a project called "STEM for Disadvantaged Students Especially Girls" to help socioeconomically disadvantaged students and especially girls in be more interested in STEM education in April, 2014. This project which covers several examining, researching, education and application activities aim to increase students' scientific process skills, creativity, problem solving and higher order thinking skills and help students form positive attitudes towards STEM related occupations (İstanbul Aydin University, 2016).
3. Training STEM Teachers

According to Kearney (2015); STEM teachers who work at schools should have the following tasks and responsibilities;

- Distributing regulations for STEM education with project based learning method in their schools.
- Participating in professional development trainings related to STEM education methods and researches that will be conducted.
- Making use of educational materials by applying learning methods which are appropriate to the educational goals of curriculum and learning processes.
- Improving learning, creativity and cooperation among students by using technology.
- Cooperating with school administration for the evaluation of applications and trainings of STEM curriculum.
- Organizing, developing and coordinating STEM activities.
- Guiding teachers about STEM attempts and educational issues.
- Increasing students’ and staff’s learning experiences by choosing best STEM resources.
- Launching new education programs with STEM vision.
- Sharing results and activities related to STEM education on social media.
- Preparing desktop version of materials to be used in science education.
Studies done for STEM teachers' in-service trainings in different countries can be summarized as following:

*Slovenia* is focused on use of technological tools in STEM in-service trainings.
Israel created an online platform where experienced teachers can share their activities used in classroom with other teachers. Reforms made has greatly contributed to the inclusion of STEM education into content, format and teaching methods. Israel also gave importance to online trainings on STEM teaching and learning.

Lithuania organized online STEM trainings for teachers. These online trainings were carried out for the reason of increasing the use of digital labs in science teaching and student proficiency.

Germany STEM Teacher Academy organized online trainings for teachers in 2014. It is planned to organize three more online trainings in 2015-2016. These online trainings are focused on the development of educational materials and their effective use in classrooms.

Estonia is focused on using technological tools while organizing online trainings for STEM teachers. Moodle courses were organized with the cooperation of universities. And teachers are informed about how to teach with Moodle. These trainings were recorded and broadcast.

Bulgaria established a Moodle platform for Mathematics and IT education. STEM teachers were aimed to practice and studying in moodle platforms.

The National Science Learning Center have been organized online in-service trainings focused on the STEM education for 10 years in England. Online trainings are organized to inform teachers about STEM education.
According to Özdemir (2016), while doing in-service training of STEM teachers in Turkey, they first should receive trainings for understanding meaning of STEM education and these trainings should cover what STEM is, how it should be and creating awareness about STEM education. STEM teacher groups can be established in schools and these groups can discuss and plan what can be done about STEM education.

The first professional development program about STEM education in Turkey is STEM teacher training program hosted by Bahçeşehir Üniversity. This programme aims to plan the best teacher training for STEM education. Teachers receive a STEM education certificate at the end of this training.
According to the researches conducted at STEM Education Centers, studies for revising of curriculum according to STEM education should start. Because of the intensity of course content load and content based centralized exams, a content based learning environment is created at science and mathematics courses in Turkey. Science laboratories in schools should be more active with STEM activities. This content oriented learning environment should be revised so that it leads students to ask questions, make researches, develop products and new inventions.
4. Updating the Curriculum

According to the researches conducted at STEM Education Centers, studies for revising of curriculum according to STEM education should start. Because of the intensity of course content load and content based centralized exams, a content based learning environment is created at science and mathematics courses in Turkey. Science laboratories in schools should be more active with STEM activities. This content oriented learning environment should be revised so that it leads students to ask questions, make researches, develop products and new inventions.

For the adaptation of STEM education, course content load of Science and Mathematics courses in primary and secondary schools should be decreased so that there will be enough time for STEM activities and centralized examination system should be updated accordingly. Students’ inquiry, researching, developing products and inventing skills should be assessed and evaluated. Science labs in school should be renovated according to STEM education and necessary course material should be provided to them.

After examining the primary and secondary school science and mathematics curriculum implemented in Turkey, the following results about inclusion of STEM education into these curricula are observed: In science and mathematics curriculum, it is aimed that students will be educated as scientifically literate individuals with knowledge, skills and positive attitudes on Science-Technology-Society-Environment (FTTC) (TTKB, 2013). This means that although science and mathematics curriculum gives importance to achievement of the interaction between science, technology and society, STEM integration and engineering skills aren’t given importance in these curricula (Kertil & Gurel, 2016).
There is also a science applications course that has been available as an elective course in all levels of secondary school since 2012-2013. The outcome of this course is to educate scientifically literate individuals who will be able to research about science, read related books and articles and improve his/her science skills. Students who know how to achieve these knowledge and skills will learn about the nature of science and find it easier to understand the scientific solutions of the problems they face (MEB, 2012).

The opinions of academicians on updates for the adaptation of STEM education into curriculum are as followings:

According to Özdemir (2016), instead of a direct revision of curriculum, a step by step update in curriculum for STEM education is necessary. Firstly, exciting activities can be included in curriculum for initiating scientific inquiry based activities. In this way, students can gain awareness of scientific inquiry. While conducting studies about curriculum, it important to consider in which stage STEM education will be used. The method in STEM education should be “tinkering method” which includes learning by doing. While adaptation of STEM education into primary and secondary school curriculum, appropriate engineering skills into these school levels should be identified. Then, especially coding should be adapted to STEM curriculum. After completing these two steps for STEM education, theoretical courses supporting the STEM applications in science and mathematics courses should be determined. It is not possible to handle only mathematics and science or only Engineering and Technology courses in the new curriculum. The STEM curriculum program should be more than the total of all pieces (Davison, Miller, & Metheny, 1995; Honey, Pearson, & Schweingruber, 2014).
There are three main necessities for adaptation of engineering into STEM education at primary schools:

- Engineering education in primary schools should highlight the engineering design.
- Engineering education in primary school should include knowledge and skills on Mathematics, Science and Technology.
- Engineering education in primary school should encourage thinking practices related to engineering.

According to the results of Integrated Teaching Project (2016), Beside science, technology, engineering mathematics subjects, the main educational goals of STEM education can also be chosen among the educational goals of environment education, media literacy, creative thinking, science applications, intelligence games, informatics applications and software, mathematical applications, communication technologies, astronomy and space science, research methods courses available in the curriculum.
For the designing of a separate course curriculum of STEM education, following six topics need to be identified (Berlin & White, 1994):

1. Learning methods
2. Knowledge gaining ways
3. Process and thinking skills
4. Conceptual knowledge
5. Attitudes and values
6. Teaching methods

While determining a separate course curriculum for STEM education, common topics in science, mathematics, technology and design, engineering, coding, etc courses should be identified and the inquiry based STEM learning activities designed for these topics should be conducted in a separate STEM course.

For example; knowledge and skills related to Science, Mathematics and Technology and Design courses can be combined by designing a student project activity about dinosaurs. For this study, students can research Dinosaurs' biological features as a science activity, calculate their ages as a mathematics activity, model a dinosaur as a technology and design activity all together in a STEM course (Davison, Miller, & Metheny, 1995).

According to Yıldırım ve Altun (2015), integration of STEM education activities into science, mathematics, technology and design, etc. courses require the identification of five topics:

1. Special course subjects
2. Content
3. Process skills
4. Learning methodology
5. Thematic relations
Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world.

Albert Einstein
Below are some educational goal recommendations about Engineering courses which isn’t available in our curriculum:

- Students research about the scope of engineering and its historical development.
- Students review the history of measurement tools and describes the inventions contributing to the functionality of a tool.
- Students collect the qualitative and quantitative data as a result of the experiment conducted, saves the observations and evaluates them.
- Students estimate the performance, reliability and failure of alternative solutions.
- Students research about the engineering branches and compares them. She also identifies the current and inter-disciplinary engineering branches.
- Students examine the research topics of engineering fields.
- Students examine how engineering applications effect humanity environmentally, economically and politically.
Students use different mathematical concepts and methods while analyzing a problem.
Students realize the importance of sensitivity in measurement and evaluation in engineering.
Students apply the mathematical formulas for analyzing the data acquired.
Students identify the processes involved in an engineering project. Also explain the stages such as planning, creating prototypes, designing, conducting, quality check and reporting.
Students successfully complete the works undertaken according to the roles they take in the project works.
Students can describe and analyze the instructions followed (e.g. describing one of the characters’ behaviors in a video managed by rules and algorithms).
Students evaluates what kind of problems they can solve by using modeling and simulation.
Students perform abstractions to break a problem into sub-problems.
Students link mathematics with computer science (binary numbers, logic, sets and functions).

In the integration of STEM learning activities into science, mathematics, technology and design, etc. courses, topics which can be taught together with the other topics in the curriculum should be determined and integrated inquiry based course activities should be planned for these topics.
According to Özdemir (2016), STEM education is a process open to development. It is necessary to identify suitable assessment and evaluation methods for STEM education. STEM education can't be evaluated in an effective way with the existing assessment and evaluation tools that are developed for measuring achievement of course content. For example in STEM schools in USA, students are seen not to be successful enough in the general content based examinations. The reason for this is not STEM education but the lack of suitable assessment and evaluation tools for STEM education. That's why assessment tools which will cover the whole STEM activity process should be chosen while preparing STEM education curriculum. Assessment tools which will measure students’ inquiry, making research, production and inventing skills should be developed. It is also seen that these tools will become more subjective than objective. Students' reaching wrong results by students in STEM activities don't mean they fail. What should be assesses is to what degree a student participates to the inquiry, thinking, researching, product development and invention creation processes. For example rubrics (graded scoring) can be a suitable solution for this assessment method transition.

In the integration of STEM learning activities into science, mathematics, technology and design, etc. courses, topics which can be taught together with the other topics in the curriculum should be determined and integrated inquiry based course activities should be planned for these topics.
Most of the STEM learning activities are based on application, process and individual or group study. That's why there is a need for course materials for students and teachers to perform inquiry, research, product development and create new inventions.

Interactive boards, tablets and Educational Informatics Network (EBA) contents within FATIH Project are the course material and tools which can contribute greatly to the STEM education activities which aim to help students gain questioning, inquiry researching, product development and invention skills. That's why we think that FATIH Project and EBA set a suitable ground for STEM education.

Skill developments such as questioning, researching, product development via using the knowledge produced with an interdisciplinary approach, inventing and making innovations can be accelerated with the use of information technologies in STEM education.

Therefore we think that it is necessary to use hardware and software provided within FATIH Project in STEM education. Each student can develop his/her skills in inquiry, making research, product development and creating new inventions by using their coding skills with their tablet computers provided with FATIH project.
5. Creating STEM Education Environments and Providing Necessary Laboratory Materials to Schools

After curriculum is updated appropriate to STEM education, STEM integration into curriculum can be provided with establishing appropriate STEM learning environments and providing necessary laboratory materials to schools.

Most of the STEM learning activities are application, process and group work based. That's why there is a need for laboratory materials STEM learning activities based on questioning, research, product development and creating inventions (Baran, Canbazoğlu-Bilici, & Mesutoğlu, 2015). From this point of view, it can be said that supporting activities which will contribute to development of STEM skills, giving students opportunities so that they can produce, encouraging their questioning skills so that they are aware of their work should be considered while establishing STEM education environments in primary and secondary schools.

Interactive boards, tablet computers and Educational Informatics Network (EBA) contents within FATIH Project are the course materials and tools which can contribute greatly to the STEM education activities which aim to help students gain questioning, researching, product development and creating new inventions skills. That's why FATIH Project and EBA portal provide a suitable ground for STEM education.
It is necessary to make use of information technologies in all teaching and learning processes of STEM education so that STEM education can be brought to all people in an equal and effective way. FATİH Project (Action of Enhancing Opportunities and Improving Technology) aims to raise individuals with 21st century skills and create a production and innovation based society (MEB, 2010). Interactive boards, broadband internet connections, tablet computers for students and teachers, Educational Informatics Network (EBA) are the technological tools which can contribute greatly to the STEM learning environments.

FATİH Project is led by General Directorate of Innovation and Educational Technologies, Ministry of National Education. To increase the quality of education and provide equal opportunities within FATİH Project, interactive boards, broadband internet infrastructure and access and tablets computers to all students and teachers in public schools are provided for the effective use of information technologies in education. Also, a great deal of digital content is available within Educational Informatics Network (EBA).

Importance of use of informatics technologies in STEM education curriculum is highlighted. Skills such as questioning, data collection, product development with interdisciplinary approach, creating new inventions and designing innovations can be accelerated with the use of informatics technologies. Today where the traditional content based teaching and learning approach is not sufficient for STEM education, it is important to use informatics technologies which contribute to development of STEM skills and so that the opportunities provided by FATİH Project and EBA are getting more and more importance.

Also, the need for having equal opportunities and making use of informatics technologies by everyone in schools (teachers, students, administrators, etc.) who participates in STEM education process can be met by FATİH Project.
To summarize, with the use of interactive boards, broadband internet facilities, tablet computers and EBA content provided within FATIH Project in STEM education, followings can be achieved:

- Facilitating STEM education which is based on questioning, researching, product development and inventing,
- Providing an environment to students independent from time and space for STEM education,
- Supporting STEM education by using digital multimedia laboratory materials,
- Increasing the quality of information technologies used in STEM education,
- Providing equal opportunities in STEM education for children at socioeconomically low and high background,
- Helping students learn with lesson activities based on questioning, researching, product development and inventing.

To be able to use hardware, software and digital educational materials in STEM process, usage of all of these materials in STEM learning and teaching activities need to be modeled. Also providing students coding skills in the computer technologies curriculum will support STEM education. As summary, we think that it is necessary to use hardware and software provided within FATIH Project in STEM education. Each student can develop skills such as questioning, researching, product developing and inventing by using coding in her/his tablet computers.
Opinions on STEM Education

A questionnaire that include ten main questions for the purpose of getting the opinions of teachers about integration of STEM education into our education system have been prepared by General Directorate of Innovation and Educational Technologies and it was applied to teachers by "ScientixTurkiye" social media environment. The results of data analysis collected with this questionnaire study are listed as following headings:

- Create a Question / Inquiry
- Design a Product/Invention
- Test the product
- Share/Publish
- Evaluate
- Draw a Conclusion
- Think again

Figure 5. Learning Cycle of STEM Education
Distribution of answers to “It is necessary to adapt inquiry based STEM education (Science, Technology, Engineering, Mathematics) is given in the Chart 1 below:
"It is necessary to adapt inquiry based STEM education (Science, Technology, Engineering, Mathematics) in our education system."

91.97% of the participants state that it is necessary to adapt inquiry-based STEM Education (Science, Technology, Engineering, Mathematics. 4.46% of them are indecisive and 3.57% of them don't agree.
2-The Necessity of STEM Education for the Development of Economies

Distribution of answers for “STEM education is necessary for the development of economies throughout the world.” is given in the Chart 2 below:

Chart 2: Distribution of answers for “STEM education is necessary for the development of economies throughout the world.”

91.96% of the participants state that STEM education is necessary for the development of economies throughout the world. 4.46% of them are indecisive and 3.58% of them don’t agree.
3-Integration of STEM Education into Our Education System for the Development of Economy

Distribution of answers for “It is necessary to integrate STEM Education into our education system for the development of economy.” is given in Chart 3 below:

Chart 3: Distribution of answers for “It is necessary to integrate STEM Education into our education system for the development of economy.”

93.75% of the participants state that it is necessary to integrate STEM Education into our education system for the development of economy. 2.68% of them are indecisive and 3.58% of them don't agree.
Chart 4: Distribution of answers for "A strategic plan should be prepared for the transition to STEM education in Turkey" is given in Chart 4 below:

93.75% of the participants state that a strategic plan should be prepared for the transition to STEM education in Turkey. 2.68% of them are indecisive and 3.57% don't agree.
94.64% of the participants state that curriculum of primary and secondary schools should be updated for transition to inquiry-based STEM education. 0.89% of them are indecisive and only 4.47% don't agree.
6- Renewing Science Laboratories and Providing New Laboratory Equipments to Schools for the Transition to STEM Education

Distribution of answers for “It is necessary to renew science laboratories and provide new experiment equipments to schools for transition to STEM education.” is given in the Chart 6 below:

Chart 6: Distribution of answers for “It is necessary to renew science labs and provide new laboratory equipments to schools for transition to STEM education."

86.61% of the participants state that it is necessary to renew science labs and provide new experiment equipment in schools for transition to STEM education. 2.68% of them are indecisive and 3.57% of them don't agree.
7-Launching STEM Teacher Training Programs by Faculties of Education for Training of STEM Teachers

Distribution of the answers for “STEM Teacher Training Programs should be launched so that STEM course teachers can be trained by faculties of education of universities” is given in the Chart 7 below:

Chart 7: Distribution of the answers for “STEM Teacher Training Program should be launched so that STEM course teachers can be trained by faculties of education of universities"

91.08% of the participants state that STEM Teacher Training Programs should be launched so that STEM course teachers can be trained by faculties of education of universities. 4.46% of them are indecisive and 4.47% don't agree.
8-Preparing In-service training programs for science and mathematics teachers to make them STEM Teachers

Distribution of the answers for “In-service trainings should be prepared so that science and mathematics teachers can become STEM teachers.” is given in the Chart 8 below:

Chart 8: Distribution of the answers for “In-service trainings should be prepared so that science and mathematics teachers can become STEM teachers.”

91.96% of the participants state that in-service trainings should be prepared so that science and mathematics teachers can become STEM teachers. 2.68% of them are indecisive and 5.38% of them don't agree.
9- Integration of STEM Course Activities into Curriculum

Distribution of the answers for “STEM course activities should be integrated into curriculum.” is given in the Chart 9 below:

Chart 9: Distribution of the answers for “STEM course activities should be integrated into curriculum.”

95.54% of the participants state that STEM course activities should be integrated into curriculum. 0.89% of them are indecisive 3.57% of them don't agree.
10- Integration of STEM Education and Technology and Interdisciplinary Curriculum

Distribution of the answers for “Integration of STEM education and technology and interdisciplinary curriculum should be provided” is given in the Chart 10 below:

Chart 10: Distribution of the answers for “Integration of STEM education and technology and inter-disciplinary curriculum should be provided”.

95.54% of the participants state that integration of STEM education and technology and interdisciplinary curriculum should be provided. 4.46 of them are neutral and 4.46% of them don't agree.
Other Opinions of Questionnaire Participants on STEM Education

The answers of participants to the open ended questions are summarized below:

It is necessary to technological and scientific qualifications of STEM education need to be integrated with educational immediately. Physical environments and curriculum should be updated accordingly.

STEM education must be implemented in all levels of education.

Teachers graduated from Industrial Technology education can play the leading role in STEM education.

Art education should be involved in STEM education. And It should be called as STEAM.
Inquiry-based learning should be taught to curious teachers firstly. And they should receive applied trainings for a while.

If STEM is going to be integrated into primary school curriculum, teachers should get in-service trainings and kindergarten shouldn't be neglected.

The obligation of raising students according to the examination system causes rote learning based activities. It causes children not knowing why and how and it decreases the quality of education. It is very important to adopt STEM education activities as soon as possible.

STEM education should immediately be implemented starting from kindergarten.
I think that only science and mathematics teachers should teach STEM. Some teachers are also good at integrating technology into classes and work with other disciplines. I believe that inquiry-based STEM education can shed light to our students', teachers' and country's future.

Although STEM is about science, chemistry and mathematics, etc. subjects, other teachers need to be informed about STEM.

STEM education is a must in today's world.

Firstly people need to be informed about what is STEM. Information pollution should be avoided. STEM education is not given by everyone. It should be taught by experts only.

It is important to teach the related topics in STEM, getting help from businesses and factories and supporting teachers with in-service trainings.
Education should be integrated into production and industry. Innovation should be the cornerstone of education.

Teachers who can teach and learn should be trained. Students should be individuals who can ask questions and have a strong communication skills.

Researches about STEM education should be increased and generalised.

STEM education will improve students' creativity and provide them with an increased questioning skill.

Necessary in-service trainings should be provided to teachers so that STEM education can be involved in teaching.
STEM education will improve students’ creativity and provide them with an increased questioning skill.

We should give the necessary importance in STEM education so we can produce technology instead of purchasing technology.

STEM education should be applied especially in vocational schools. Students there can think and produce easier. And entering into central examinations is not compulsory for them as much as other students.

There are many studies conducted in Turkey under the title of STEM. All of them have different educational approach. I think it would be beneficial to combine all of them. STEM is important for the new generations who should be able to produce new inventions.

Instead of design of the laboratories, it is important to create STEM classrooms. Classrooms where students can study together to produce new inventions. It could be called STEM Lab.
I want to receive training about STEM education. I am a Science teacher. Curriculum can be updated according to STEM education. And STEM skills should be included into centralized exams such as University entrance and TEOG so that it increases motivation.

STEM education not only provides students with inquiry-based learning skills but also skills for handling problems with a limited amount of time and creativity.

STEM should be adopted and implemented as soon as possible. We need skills such as productivity and problem solving in our country. I think it will increase the interest in science and make learning more significant.

As a result, we reached to the conclusion that teachers give very importance to STEM education. Opinions of participants show that STEM education is necessary for our country. Also, opinions of the participants show that there are needs such as revising in curriculum, in-service trainings for teachers and adapting school infrastructure to the STEM education.
CONCLUSIONS AND RECOMMENDATIONS

21st century skills such as coming up with solutions with different approaches, systematic and creative thinking, gaining skills which will enable individuals reaching to best solutions require STEM education. STEM education is also necessary for questioning life, conducting researches, realizing problem solving skills, thinking over solutions, coming together to come up with solutions, developing product and creating a learning network by developing invention skills.

Steps to be taken as recommendations and studies needed for transition to STEM education can be summarized as following:

- STEM education should be provided to all students. Also, curious, skilled students with higher order intelligence should be detected and trained with advanced STEM education.
- An action plan outlining the STEM education prepared with the coordination of MoNE, TÜBİTAK, Universities and TÜSİAD can be developed and shareholders’ responsibilities and roles can be identified.
- STEM education centers should be established and these centers should provide STEM education support for teachers and students. STEM education researches and projects can be conducted at these non-profit STEM education centers where expert educators and academicians work at.
- In-service trainings can be provided to teachers for the purpose of promote STEM education at STEM centers. In these trainings, teachers can gain awareness about what STEM is, how STEM education should be, etc. Successful studies and teachers’ success stories can be announced by these centers.
- TÜSİAD, industrial institutions, companies, universities and Ministry of National Education (MoNE) should meet in a STEM centers for creating and revising a STEM curriculum.
- Needs analysis studies should be conducted by STEM centers for the integration of STEM education into curriculum programs.
- While working on integration of STEM education into the existing education system, a gradual integration strategy based on the results of the researches should be followed without in a hurry.
- To integrate STEM education into curriculum, huge content load in primary and secondary school education on science and mathematics courses can be reduced so that STEM education activities should have more place in these courses.
- Transition to STEM education in terms of updating curriculum shouldn't be done at once but step by step. Firstly exciting initiative STEM activities should be included in curriculum then advanced STEM course activities can be applied.
- While integrating STEM into curriculum it is important to consider in what stage STEM education will be used. The method to be used in STEM education activities can be “tinkering metod” which includes learn by doing.
- Centralized content based examinations should be revised and updated in a way that they will measure questioning, researching, product development, inventing and innovation skills.
• After the completion of the integration of STEM education into curriculum, teachers can be supported with in-service trainings on STEM so that they can include knowledge and skills learned in these trainings into their annual course and lesson plans.

• STEM education should be integrated into pre-service teacher training programs according to the results studies done by STEM centers.

• Teachers who work in all 81 cities of Turkey should be able to receive in-service trainings in STEM centers founded in all cities.

• STEM education groups can be built by teachers and experts at schools. These groups can plan what can be done for integration of STEM education.

• Necessary laboratory materials and other material needs of schools for STEM education according to results of researches done by STEM centers should be identified and provided.

• Interactive boards, tablets and EBA opportunities provided within FATİH Project should be used in schools for STEM education activities.

• Studies for increasing the e-content and learning activities suitable for STEM education should be included into EBA portal of FATİH Project.

• STEM education competitions for questioning, researching, product development, invention and designing skills of students can be organized.

• Teachers’ and students’ STEM education projects should be supported and rewarded.

• In Computer Technologies course curriculum coding skills should be thought in a manner to support STEM education.

• Activities and conferences for the promotion of STEM education should be organized.

• While planning STEM education curriculum programs, principle of equality should be considered for all students from every kind of socioeconomic background.
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ANNEX


For the transition to STEM education in our country a set of action recommendations have been identified as given below:

**ACTIONS**

1. Creating a STEM education working group.
2. Establishing STEM education centers by collaboration with other related institutions.
3. Conducting research studies in STEM centers to generalize STEM education in Turkey.
4. Preparing a STEM action plan for the transition to STEM education according to the results of the researches conducted in STEM education centers.
5. Organizing seminars about STEM education by STEM centers to the personnel work in MoNE education units, board of education, provincial directorates of MoNE, school administrators and teachers.
6. Decreasing content load in Science and Mathematics courses in schools so that there will be enough time for STEM course activities and updating centralized content based examination system accordingly to measure students’ inquiry, researching, developing products and inventing skills.
7. Renewing science laboratories of schools and providing new laboratory equipments for the transition to STEM education in primary and secondary schools.
8. Launching STEM teacher training programs within the faculties of education of universities.
9. Preparing and implementing in-service STEM education programs for science, mathematics, technology and etc. teachers who want to be STEM teacher.
<table>
<thead>
<tr>
<th>ACTION NO</th>
<th>ACTION</th>
<th>RESPONSIBLE INSTITUTION</th>
<th>COLLABORATION INSTITUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Creating a STEM education working group</td>
<td>MoNE (Board of Education, Education Units, YEGITEK)</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
<tr>
<td>2</td>
<td>Establishing STEM education centers by collaboration with other related institutions.</td>
<td>MoNE (Board of Education, Education Units, YEGITEK)</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
<tr>
<td>3</td>
<td>Conducting research studies in STEM centers to generalize STEM education in Turkey.</td>
<td>MoNE (Board of Education, Education Units )</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
<tr>
<td>4</td>
<td>Preparing a STEM action plan for the transition to STEM education according to the results of the researches conducted in STEM education centers.</td>
<td>MoNE (Board of Education, SGB and Education Units)</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
<tr>
<td>5</td>
<td>Organizing seminars on STEM education by STEM centers to the personnel of MoNE education units, board of education, provincial directorates of MoNE, school administrators and teachers.</td>
<td>MoNE (Board of Education, ÖYGGM, Education Units)</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
<tr>
<td>6</td>
<td>Decreasing content load in Science and Mathematics courses in schools so that there will be enough time for STEM course activities and updating centralized content based examination system accordingly to measure students’ inquiry, researching, developing products and inventing skills.</td>
<td>MoNE (Board of Education, Education Units)</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
<tr>
<td>7</td>
<td>Renewing science laboratories of schools and providing new laboratory equipments for the transition to STEM education in primary and secondary schools.</td>
<td>MoNE (Board of Education, ÖDSGM, Education Units)</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
<tr>
<td>8</td>
<td>Launching STEM teacher training programs within the faculties of education of universities.</td>
<td>YÖK Universities</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
<tr>
<td>9</td>
<td>Preparing and implementing in-service STEM education programs for science, mathematics, technology and etc. teachers who want to be STEM teacher.</td>
<td>MoNE (Board of Education, ÖYGGM, Education Units)</td>
<td>TÜSIAD, TÜBİTAK, Universities</td>
</tr>
</tbody>
</table>
Annex 2: Websites on STEM Education

- http://scientix.eu/ (11.03.2016)
- https://www.facebook.com/groups/ScientixTurkiye/ (11.03.2016)
- https://twitter.com/ScientixTurkey (11.03.2016)
- https://m.facebook.com/Hacettepe-STEM-Maker-Lab-7448669522…/ (12.03.2016)
- http://www.stemandmakers.com/ (12.03.2016)
- horizon2020 (18.03.2016)
- https://www.academia.edu/3388136B%C3%BC%C3%9Fretmenlik_Projesi_2016__STEM-FeTeMM_%C3%96%C4%9Fretmen_B%C3 %BCnten_1_1_ (21.03.2016)