**E-STEAMSEL PROJECT**

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STEAM Studies in [European Countries](#_heading=h.1fob9te)

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# 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 (Çakıroğlu, 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)

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| STEM education is an iterdisciplinary approach which covers the whole process from kindergarten to higher education |

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| 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. |

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| 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. |

 **Components of STEM Education**



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| 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. |

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| Teachers' role is helping students reach the level of higher order thinking, product development, invention and innovation by leading but not teaching theoretical knowledge to them on Science, Technology, Engineering and Mathematics. It is important to create a learning environment where students aren't afraid of failing and are confident. |

# 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:

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| STEM education is seen as one of the most important elements in maintaning 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 projectbased 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) |

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|  **China** has gave great importance in science education and stated that science is the main block for a developed society for many years. Science teaching in 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). |

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| **Russia** has focused on reinforcing higher education institutions within the national education strategy. They also has focused on completing the missing points with new curriculum programs. Government has published three initiative item 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

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| **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. |

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| **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. |

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| 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 |

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| 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. |

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| 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 |

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| 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.  |

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| 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. |

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|  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.  |

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|  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.  |

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|  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.  |

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|  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. |

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|  **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  |

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| **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-reated. 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.  |

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|  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. |

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|  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. Morever, related institutions, universities and other organizations have their own STEM education strategies. |

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

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|  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 |

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|  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.  |

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|  Italy is aware of the importance of STEM education although it doesn't have a specific STEM education strategy. |

#  STEAM EDUCATİON AT TURKEY

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 (TUSİAD) that the employment rate of people who graduated from STEM education department of universities is 19% (TUSİAD, 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 (TUSİAD, 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 (TUSİAD, 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. 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.



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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.

# An Opportunity for STEM Education: FATİH and EBA

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. FATIH 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, broad band 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, broad band 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).

# STEAM EDUCATİON AND GENDER EQUALTY in TURKEY

The Strategic Plan of the Ministry of National Education for 2015-2019 aims to strengthen STEM education but does not contain a policy which approaches the issue from a gender perspective. Under a regulatory amendment published in the Official Gazette on September 12, 2019, the Ministry removed the term “gender equality” from the scope of activities. Civil society organisations and the private sector are observed to have been conducting many activities with girls in recent years, both in schools and outside schools, in order to overcome gender inequality in this area. The exclusion of “gender equality” from the Ministry directive as of 2019 has removed the basis for carrying out activities for girls in schools that make equal access possible for children studying in formal education.

Global surveys indicate that socioeconomic and gender inequalities in Turkey are on the increase. If girls are not provided with the opportunity of equal access to quality education, taking the inequalities in STEM education into account, female poverty and gender inequality are likely to go on rising. Another point that needs to be emphasised is that if cooperation and coordination is not restored at the level of public institutions – and particularly between the Ministry of National Education and civil society organisations – in STEM activities directed towards girls, then the inclusiveness of the activities conducted outside schools will be reduced, they will no longer be able to reach different socioeconomic segments, and new types of inequality will come into being.

According to UNDP data, the proportion of women among graduates of STEM subjects is 34.7%, This points to the existence of a gender gap in participation in the STEM subjects. The field data shed light on the social origins of this gap.

Girls are observed to be very interested in STEM subjects, but these subjects are most commonly associated with the professions of engineer and scientist, and the variety of professions related to STEM is not sufficiently well known. There are also striking differences between findings from different types of schools, which draws attention to socioeconomic inequalities.

In addition, a strong relationship is observed between knowledge of the STEM domains and the desire to choose a profession related to STEM. From the point of view of activities to strengthen the participation of girls, this finding demonstrates the importance of promoting knowledge of the STEM domains. Meanwhile, the regional variations observed in the level of interest in STEM-related professions indicate a clear potential for the provision of support in this respect.

# Recommendations and Steps for Adaption of STEM Education in Turkey

1.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.

2. 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.

3.Conducting STEM Education Researches:After establising STEM education centers, conducting researchers about for 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.

4. Training STEM Teachers : 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.

5. 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.

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