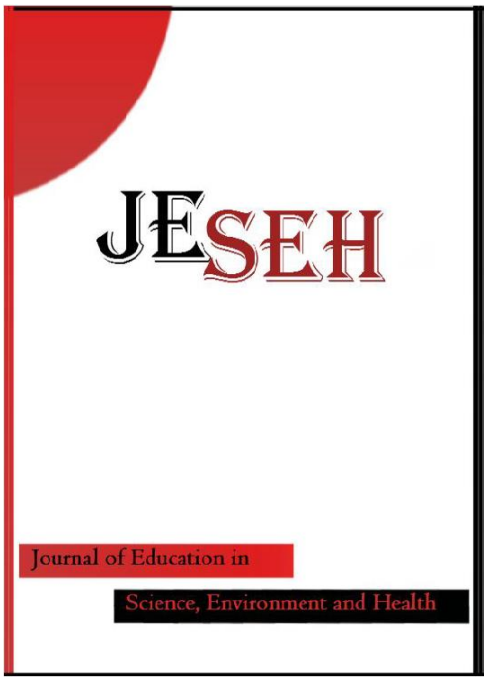

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STEM Applications in Turkish Science High Schools

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Abstract

The idea of establishing Science High Schools in Turkey was discussed in a multilateral project at the beginning of 1963. The Ministry of National Education (MoNE), Ford Foundation, Middle East Technical University (METU), Ankara University, and International Development Agency (AID) participated in this project to establish these schools. In Ankara, Science High School project was a US funded and technically supported project, carried out jointly by the Florida State University, METU, and Ankara University. Science High Schools' organizational goals were: (1) to improve students' ability and increase their intelligence in science (2) to increase the number of qualified personnel in higher education and industry, and (3) to develop more laboratories by increasing students' scientific knowledge in order to be the center of research and development. MoNE created the "Science High School Project Advisory Board" with six members from Ankara University and four members from METU to contribute to the scientific and curriculum aspects of the project. The Advisory Board selected 30 teachers from Mathematics, Chemistry, Physics and Biology disciplines by written and oral exams from the existing high schools of MoNE from all over the Turkey. Selected science teachers received special training for the development regarding the assessments of subjects and provided with opportunities to study on the curriculum at some universities in the United States (U.S.). To train teachers in Turkey, a modern building was constructed at METU campus and the education at Ankara Science High School started in 1964. After the success of the Ankara Science High School, the MoNE started the Science High School Projects in Istanbul and Izmir. Today, there are 238 Science High Schools serving as public schools and the same amount of schools serving as private schools. In the U. S., the training of 100K STEM teachers started in 2012. In this article, Science High Schools' development and their innovation activities, the STEM projects and the vision for increasing the STEM education in Turkey and other developed countries were discussed.

Key words: Science high schools, STEM education, MoNE

Introduction

The launch of Russia's first satellite on October 4, 1957 had an important impact on the U.S. education policies. The tension of the Cold War increased by the launch of Sputnik-1 (Bybee, 2010). This was a shock for the U.S. and created an awareness of the need for improving science. The development of physics education in the American educational system was the first work in this direction (Daeschner, 1965). Then, chemistry, mathematics and biology education were reviewed (McInerney, 1986; Saritha, 2014; School Mathematics Study Group, 1958-1977). In these areas, Massachusetts Institute of Technology (MIT) and other well-known universities, non-governmental organizations, public and private institutions and organizations involved in forming a working group including teachers to review all publications and studies to develop the curriculum and prepare new school books. These studies were transferred to Turkey in the 1960s called as the modernization of physics, chemistry and mathematics education. The system was pre-tested at Bahçelievler High School, Gazi High School and Ankara Atatürk High School. The Ankara Science High School began training in 1964 with the technical and financial support of Ford Foundation at METU campus with allocated 120 acres of land (Regulation on Science High School, 1975; Zabun, 2007).
The objective of science high schools was defined in Secondary Education Institutions Regulation of MoNE published in the Official Gazette on September 7, 2013, no: 28758 as following:

- To graduate students with bodily, mental, moral, spiritual, social and cultural characteristics in the direction of development of democracy and respect for human rights, equipping them with the knowledge and skills required to prepare for the future,
- To prepare students at the secondary level for life and higher education by providing a common public culture and profession,

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- To construct a healthy, balanced, and a dynamic school and education structure in accordance with the principles and policies of the MoNE and the employment relationship,
- To rise students' self-confidence, self-control and develop their sense of responsibility,
- To improve students' working habits and teamwork skills
- To improve students' creative and critical thinking skills,
- To follow the developments and changes to teach foreign languages
- To support students to develop projects to use their information to produce new knowledge and skills,
- To take advantage of technology to increase the quality of the education,
- To promote lifelong learning for all individuals,
- To encourage education and training services and certification to ensure compliance with international standards,
- To enhance students' vision in a scientific way.

These objectives of Science High Schools indicate today's Science, Technology, Engineering and Mathematics (STEM) education (Erdogan & Stuessy, 2015a; Erdogan & Stuessy, 2015b). The following teams and councils were established to ensure the efficiency of government activities in order to develop STEM education with; the realization of the importance of school and environment cooperation, the support of local authorities and civil society organizations, and the development of cooperation with all types of institutions:

- Teachers Council
- Teacher's Board for a specific course and subject
- Group of Teachers Council
- School Student Council
- School Student Awards and Disciplinary Committee
- Honorary Board
- Social Activities Committee
- Science Consulting Art Design Boards

It would be inevitable to say that the Science High Schools were successful to carry out the objectives so that along fifty years, hundreds of highly qualified graduates were attended to METU and other high-ranking universities in Turkey as well as abroad. Thus, the MoNE started initiating more than 200 science high schools between 1964-2014 in Turkey. Since 2010s, the private science high schools were started using the same curriculum as a model.

Table 1. Weekly hours for science high school curriculum in the 1964-1965 school year

Courses	First Year	Second Year	Third Year		
			Physics Branch	Chemistry Branch	Biology Branch
Basic Math	4	4	4	4	4
Geometry	3	2	2	2	2
Science	6 (lst term)	0	0	0	0
Physics	3 (2nd term)	4	6	0	0
Chemistry	3 (2nd term)	4	0	6	0
Biology	4	4	0	0	4
Literature	4	4	4	4	4
History	0	3	0	0	0
Geography	3	0	0	0	0
Social Science	0	0	3	3	3
2nd Language	5	5	5	5	5
Sport	1	1	1	1	1
National Security	1	1	1	1	1
Elective Courses	5	4	7	7	7
Total	36	36	36	36	36

(Source: Ankara Science High School Project, 1964)

Method

Our work in this monograph was initiated by examining Ankara Science High School project and the protocols at the establishment phase and the legislation in different ways. The numbers of high school graduates placed to STEM education in the university were reviewed.

Table 2.Comparison of weekly hours for three different high school curricula

	Anatolian High School					Science High School					Social Science High School					
	Grade					Grade					Grade					
Course Name	9	10	11	12	Total	9	10	11	12	Total	Hz	9	10	11	12	Total
Turkish	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
Language and expression	2	2	2	2	8	2	2	2	2	8	0	2	4	4	4	14
Turkish literature	3	3	3	3	12	3	3	3	3	12	0	3	4	4	4	15
Religious culture and moral knowledge	1	1	1	1	4	1	1	1	1	4	0	1	1	1	1	4
History	2	2	0	0	4	2	2	0	0	4	0	2	4	3	0	9
Turkey revolution history and Kemalism	0	0	2	0	2	0	0	2	0	2	0	0	0	2	0	2
Contemporary Turkish and world history	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4
Geography	2	2	0	0	4	2	2	0	0	4	0	3	2	4	4	13
Mathematics	6	6	0	0	12	6	6	6	6	24	3	6	6	6	6	27
Physics	2	2	0	0	4	2	2	4	4	12	0	2	2	0	0	4
Chemistry	2	2	0	0	4	2	2	4	4	12	0	2	2	0	0	4
Biology	3	3	0	0	6	3	3	3	3	12	0	3	3	0	0	6
Health information	1	0	0	0	1	1	0	0	0	1	0	1	0	0	0	1
Philosophy	0	0	2	0	2	0	0	2	0	2	0	0	0	2	0	2
First foreign language	6	4	4	4	18	7	3	3	3	16	20	6	3	3	3	35
Second foreign language	2	2	2	2	8	2	2	2	2	8	4	2	2	2	2	12
Physical education	2	2	2	2	8	2	2	2	2	8	2	0	0	0	0	2
Visual arts	1	1	1	1	4						0	2	2	0	0	4
Traffic and first aid	0	0	0	1	1	0	0	0	1	1	0	0	0	0	1	1
Counseling and guidance	1	1	1	1	4	1	1	1	1	0	1	1	1	1	1	5
Social science studies	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	6
Psychology	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Sociology	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	4
Logic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
Ottoman Turkish	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	6
Applications of mathematics	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	0
Science applications	0	0	0	0	0	0	3	3	3	0	0	0	0	0	0	0
Total main course hours	36	33	20	17	106	36	36	40	37	130	34	36	40	40	38	188
Weekly total hours	40	40	40	40	160	40	40	40	40	160	34	40	40	40	40	194

In this study several doctoral dissertations, MoNE e-school database, and yearly reports were examined and related statistics were collected. The archive scanning was performed. The latest activities and capacity of Bronx High School in the U.S., which was visited later in 1964 as a successful model for the Ankara Science High School, were observed to compare the development by the years (The Bronx High School of Science, 2016). Interviews were conducted with Ankara Science High School graduates, students, and teachers.

Results and Discussion

Different curricula with minor changes have been implemented over the years at Ankara Science High School. The first curriculum at 1964-1965 is given in Table 1. The decisive point in the preparation of the curriculum had been the weight of science courses. Share of class hours for science high schools except foreign language and sport was more than 65% of the total weekly hours. Later, this ratio was revised as %60 in 1993 (MoNE, 1993). More lectures have been taken place in accordance with the objectives of science high school on cultural and social sciences. In the 1999 regulations, while maintaining the weight of in-class education, more importance was given to the laboratory practices. The program, which is currently being implemented, is given in Table 2 that compares the high school curriculum with standard curriculum of other high schools. When the weekly hours for mathematics was compared between Science High School and Anatolian High Schools, the weekly hours for mathematics was twice more in Science High School than Anatolian High Schools. This occasion was similar for biology subject for three types of schools. The weekly hours for physics and chemistry subjects were three times more in Science High School than other two types of schools.

In Science High Schools, total weekly course time is double in mathematics and biology, and triple in physics and chemistry. The first Science High School started to serve students in 1964-1965 academic year and had been serving as the first and only Science High School for 18 years until the second one was opened in 1982. Until 2009, the maximum number of operating schools was eight. In 2009-10 and the following three years, the number of schools increased much more than previous years. In 2014-2015 Teachers High Schools were converted to Science High School and 81 new science high schools started their new training preparation**.**

Table 3.Number of science high schools by year

Start of Education Year	Number of Schools	Start of Education Year (Continued)	Number of Schools (Continued)
1964-1965	1	1999-2000	5
1982-1983	1	2000-2001	2
1983-1984	1	2001-2002	6
1984-1985	1	2002-2003	4
1985-1986	1	2003-2004	3
1986-1987	1	2004-2005	7
1987-1988	1	2005-2006	2
1988-1989	1	2006-2007	7
1989-1990	5	2007-2008	4
1991-1992	1	2008-2009	3
1992-1993	3	2009-2010	12
1993-1994	3	2010-2011	20
1994-1995	6	2011-2012	26
1996-1997	8	2012-2013	4
1997-1998	3	2013-2014	6
1998-1999	3	2014-2015	81
Total			232

(Source: MONE E-School, 2015)

There are 159 high schools serving with 3735 teachers. The standard capacity of these schools in terms of permanent staff is 3957. The average number of students per school is 350. The percentages for female and male for overall students are 67.5 and 32.5, respectively. In 2015, 15 Science High Schools from various provinces were selected as “STEM Project School” to develop new and innovative training programs. The list of them is given in Table 4.

Table 4. MoNE STEM Project for science high schools

City	County	Name of School
Adana	Seyhan	Adana Science High School
Ankara	Çankaya	Ankara Science High School
Antalya	Döşemealtı	Yusuf Ziya Öner Science High School
Bursa	Nilüfer	Tofaş Science High School
Diyarbakır	Yenişehir	Rekabet Kurumu Cumhuriyet Science High School
Erzurum	Palandöken	Erzurum İbrahim Hakkı Science High School
Gaziantep	Şehitkâmil	Vehbi Dinçerler Science High School
İstanbul	Kadıköy	İstanbul Atatürk Science High School
İstanbul	Fatih	Çapa Science High School
İzmir	Bornova	İzmir Science High School
Kayseri	Melikgazi	Kayseri Science High School
Malatya	Yeşilyurt	Malatya Science High School
Mersin	Yenişehir	Eyüp Aygar Science High School
Şanlıurfa	Karaköprü	Şanlıurfa Science High School
Van	Edremit	Türk Telekom Science High School

(Source: MoNE E-Okul, 2015)

The development of private sector in K-12 education is an important factor to analyze the change in Turkey. From 2006 to 2014, more than 30% of public science high school students were graduated from the private middle schools (seeTable 5).

Table 5.Student source of public science high schools from different type of middle schools

Year of Education	Private Middle School	Public Middle School	Total
2006-2007	2,463	5,087	7,550
2007-2008	2,644	5,129	7,773
2008-2009	2,918	5,961	8,879
2009-2010	3,570	7,723	11,293
2010-2011	4,128	9,249	13,377
2011-2012	5,390	10,422	15,812
2012-2013	6,148	14,399	20,547
2013-2014	9,003	22,735	31,738
Total (%)	36,264 (31)	80,705 (69)	116,969 (100)

(Source: MoNE E-School, 2015)

Private Science High Schools

There are 58 private science high schools in Istanbul, 30 in Ankara, 18 in İzmir, and 231 in total. Their capacity is 35,593 students; however, currently 19,251 students are enrolled. Accordingly, the occupancy rate is 54% as of April 6, 2015. MoNE decided to allocate 3,500 Turkish Liras per student per year according to the law no 6528 in 2014-15 if parents have their child register to the private schools. Totally 168,310 students were supported and 33,749 of them registered to private schools. Out of 33,749, 2,069 students registered to the private science high schools. Accordingly, the capacity usage in private science high schools was increased by 6%. MoNE expects that the capacity usage of these schools will increase more in the next years up to 90% and also new private high schools will begin to serve students. The numbers of public and private science high schools are nearly the same, but the quota and capacity utilization is normally higher in public schools. However, the number of students per classroom is lower at the private science high schools.

When the distribution of public and private science high schools by the region is taken into consideration, there are eight private science high schools separately in Ankara and Antalya. Both cities have the highest number of science high schools in comparison to other cities whereas Şanlıurfa has the second highest number of private science high schools. During the period of 1990-2011, the ratio of male students had continuously decreased and the ratio is nowadays around 50%. The percentage of female and male public science high school graduates attended to STEM related majors at higher education is given in Table 6. The Faculty of Engineering is ranked as first with 45.5% and Faculty of Medicine with 25.3% is ranked as the second. It is observed that 70% of science high school graduates attended to STEM related majors after the high school. There are 5.881

permanent teacher positions in public science high schools. This corresponds to approximately 26 teachers in each school.

Table 6. The distribution of MoNE science high school graduates to faculties

Faculty	Female (%)	Male (%)	Total (%)
School of Medicine	10.5	14.8	25.3
Faculty of Engineering and Architecture	10.1	33.5	45.5
Faculty of Dentistry	1.7	1.5	3.2
Faculty of Law	0.2	0.3	0.5
Faculty of Economics and Administrative Sciences	1.7	6.3	8.1
Faculty of Arts and Sciences	3.4	3.6	7.0
Faculty of Education	1.7	1.6	3.3
School of Pharmacy	1.3	1.2	2.5
Faculty of Agriculture	0.3	0.4	0.7
Faculty of Veterinary Medicine	0.4	1.0	1.4
School for Open Learning	0.4	0.7	1.1
Vocational Schools	0.1	0.2	0.3
Health Vocational Schools	0.5	0.3	0.7
Others	1.5	1.0	2.5
Total	33.7	66.3	100.0

(Source: MoNE E-School 1990-2011)

As the number of private schools had been increasing, the number of students graduating from private science high schools has been increasing since 2008. The fund given by MoNE is one of the dominant factors in this increase. In 2013, the number of graduates from public science high schools dramatically increased.

Table 7. Number of graduates from science high schools

Year of Education	Private School	Public School	Total
2008-2009	2,393	4,490	6,883
2009-2010	2,097	4,735	6,832
2010-2011	2,295	5,276	7,571
2011-2012	2,327	5,442	7,769
2012-2013	2,639	6,252	8,891
2013-2014	2,919	8,380	11,299
Total	14,670	34,575	49,245

(Source: MONE E-School, 2014)

As shown in Table 8, from 1967 to 2014, 4300 students graduated from Ankara Science High School in total. Over the years, all students got acceptance from universities but three. The distribution of placement according to the faculties is 43.3% to Medical Faculties and 49% Engineering Faculties.

STEM Applications in the US

On October 4, 1957 the USSR sent the Sputnik-1 satellite from the Baikonur Cosmodrome in Kazakhstan to the orbit of 250 km. The success of Russia had a significant impact on the U.S. government and citizens. Shortly after the Sputnik satellite, the U.S. had concerns because of not sending the very first satellite (Bybee, 2010). The Cold War and the Space Fair triggered the revision of the system, so the rocket science and space science brought to the attention and financial resources allocated to projects increased. Success of Japan in the 1980s constituted the second most important influence for the U.S. education system. It was observed that a similar success, which was a threat to the U.S., was achieved by China, India and Brazil during 2000-2010. Therefore, the U.S. has started several reform initiatives and the very well known of these initiatives was the one in 1996. National Science Education Standards were published within the scope of the science curriculum to give direction to schools on how to teach (National Research Council, 1996). This program was the basis for both the development of the U.S. and STEM program (Erdogan & Stuessy, 2015a). In 2012, the scope of the Next

Generation Science Standards was established in accordance with the basic standards established in the 1996 (Achieve, 2013; National Science Teachers Association, 2014); thus, the standards of 15 laboratories in STEM disciplines have been published. No Child Left Behind Act (2001) and The Every Student Succeeds Act (2015) were the important developments for Turkey as well. Therefore, the Education Faculties of all universities in Turkey accelerated their research studies on STEM, many scientific projects started and thesis published, and many articles being published at scientific journals.

Table 8. The faculties selected by Ankara Science High School Graduates as student numbers

Year	Number of Graduates	Medical Faculty	Eng. Faculty	Others	Total
1967	96	24	60	12	96
1968	96	19	60	17	96
1969	96	7	75	14	96
1970	96	14	71	11	96
1971	95	23	67	3	95
1972	95	26	69	0	95
1973	96	28	66	2	96
1974	96	45	48	3	96
1975	96	65	31	0	96
1976	96	75	18	3	96
1977	89	60	26	3	96
1978	85	51	30	4	96
1979	84	58	20	6	96
1980	73	70	13	0	96
1981	96	87	8	1	96
1982	90	70	20	0	90
1983	85	70	15	0	85
1984	88	62	20	6	88
1985	96	30	57	9	96
1986	89	25	60	4	89
1987	94	17	72	5	94
1988	92	49	39	4	92
1989	94	29	64	1	94
1990	95	13	45	37	95
1991	94	26	52	13	94
1992	88	35	44	4	88
1993	95	33	45	17	95
1994	23	9	10	4	23
1995	58	25	25	8	58
1996	24	9	10	5	24
1997	93	18	72	5	93
1998	94	27	66	1	94
1999	90	26	60	4	90
2000	89	25	60	4	89
2001	94	30	50	4	94
2002	92	49	39	4	92
2003	90	30	56	4	90
2004	91	27	52	12	91
2005	89	35	44	10	89
2006	94	38	46	10	94
2007	93	48	36	9	93
2008	92	52	30	10	92
2009	92	39	48	7	92
2010	90	44	35	9	90
2011	94	48	37	9	94
2012	92	52	30	10	92
2013	90	46	38	6	90
2014	98	52	40	6	98
Total	4,247	1,840	2,079	339	4,300

(Source: Ankara Science High School, 1967-2014)

The main subject of the national and international conferences organized in Turkey is how to develop the STEM education in Turkey and how to adapt it to our school-curriculum (Akgündüz et al., 2015). The private sector is much more flexible and faster to adapt STEM education. MoNE also works hard on STEM education by conducting pilot studies in selected the Ankara Science High School and others, which were listed in Table 4.

STEM education is an interdisciplinary concept (Corlu, Capraro, & Capraro, 2014; see Figure 1). The selection of different faculties by science high schools graduates reflects this concept. A resistant STEM pipeline also needs some scientific and financial support. Turkey currently does not have STEM program at the national level, but STEM education related organizations and their increasing activities would be a base for a national STEM Program. The EU supported projects also raise the capacity and develop the network between the stakeholders in Turkey. In addition, TUBITAK announced funds for STEM programs running in science high schools.

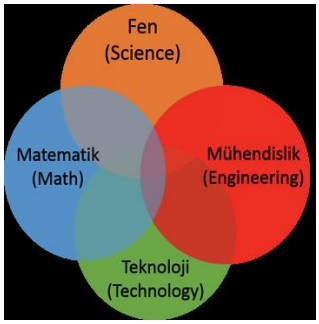

Figure 1. STEM Education

Some STEM applications done by Virginia Thomas Jefferson Science and Technology High School (2015) graduates in the research labs are presented in the following list:

- Astronomy and Astrophysics
- Automation and Robotics
- Biotechnology and Life Sciences
- Chemical Analysis and Nano Chemistry
- Communication Systems
- Computer Aided Design
- Computer Systems
- Energy Systems
- Multidisciplinary Research
- Microelectronics
- Mobile and Web Application Development
- Neuroscience
- Oceanography and Geophysics Systems
- Quantum Physics and Optics
- Prototyping and Engineering Materials

Supports by TUBITAK for STEM Education

The projects supported under TUBITAK Science and Society program was for to use STEM approach in the projects that are useful to the community in an understandable format where the information is supported by visual tools and interactive applications (The Scientific and Technological Research Council Of Turkey, 2015). In this project, the main goal is to trigger the participants' curiosity, for research and learning by making them to realize simple scientific facts, not by transferring the knowledge.

TUBITAK 4003 Program of Science and Technology Centers

This program was designed to bring people from different ages and different backgrounds together around science by providing information resources and to trigger their interest in experimental and applied sciences

(The Scientific and Technological Research Council Of Turkey, 2015). The purpose of the program is also to increase participants' interest in and attention to science. These centers are expected to increase creativity. Along with their contribution to the science, these centers also have exhibited the history and culture of the regions in which they are located. They present a combination of art and science because the submission of scientific knowledge requires creativity and an artistic perspective.

Science centers can help participants to broaden their horizon by using scientific approaches for explanation of daily events. Everyone can demonstrate creative thinking because creative thinking is a skill that can be improved. In particular, visitors can decide on their own whether to contribute to young or adults. Science centers are the center of attraction not only because of their content but also because of the structure within a diversity of green space. Large entrance and waiting room with high ceilings offer a comfortable environment for guests. The entrance with interactive outdoor science center exhibits invites them to the mysterious world of science.

TUBITAK aims to develop scientific thinking, to spread the scientific knowledge, to create a culture among the society, to promote asking questions, to raise pioneering individuals, to provide a new vision for society, and to take the leap in science that Turkey has needed by generalizing science centers in Turkey. Science and Technology Committee 23 meeting was arranged to increase the interest and curiosity of every individual, especially children and youth, in science and technology in all metropolitan cities as of 2016. Outcomes of the science centers will be more accurate in 2023. Policy makers decided to cooperate with local governments to establish these centers in all provinces.

TUBITAK 4004 Nature Education and Science High Schools Program

The aim of this program is to transfer the knowledge to the society in a comprehensive manner while using visualization tools and interactive applications. The main goal in this program is to trigger the participants' curiosity and ambition for the research, query, and learning by making them to realize simple scientific facts, not by transferring the knowledge (The Scientific and Technological Research Council Of Turkey, 2015). 289 projects were carried out between 2007-2012. The aim of this program is:

- To popularize the science and scientists,
- To emphasize the entertaining part of science,
- To overcome prejudices, negative concerns about science and scientists in society and student concerns,
- To build bridges between the school and research organizations
- To develop scientific process skills,
- To provide an understanding of the nature of science,
- To understand the interaction among science technology, society, and individuals,
- To provide sources from outside of the school according to the call to ensure the use of objective,
- To use original methods and techniques to promote the effective use of materials,
- To share scientific expertise to promote activities for the development of new content,
- To develop higher-order thinking skills,
- To enable the delivery of meaningful answers to questions regarding everyday life
- To ensure understanding of the technological activities and their relationship to the welfare of the society
- To improve environmental awareness and sensitivity with a scientific standpoint,
- To promote science literacy,
- To transfer best practices and to adapt issues related to the call,
- To promote activities in the framework of the concept for "citizen science",
- To use Web 3.0 (the Semantic Web) technology for their activities and to improve the formation of call to spread.

TUBITAK 4005 Science and Society Innovative Activities and Practices Program

This program was related to the topics about teachers' training. The program aims to arouse teachers' interest, to teach the content knowledge and improve skills to increase their motivation, to develop positive attitudes, to gain innovative approaches through interactive methods and techniques in science related subjects, and to raise the awareness of teachers in innovative approaches outside the traditional teaching methods, strategies, and

techniques for implementation in their teaching environment (The Scientific and Technological Research Council Of Turkey, 2015). With all these intentions 11 projects were supported in 2014. Some examples to achieve the objectives under this program are presented in the following paragraphs.

Quantum Physics and Optics Laboratory offer exciting opportunities for computerized monitoring of research and applied physics. Students in applied research frequently learn theoretically and experimentally with new devices in optical, electromagnetic, acoustic, nanotechnology, photonics and systems. In optical projects, imaging systems, vision sensors, color, human perception, image processing, holography, laser interferometry and other applications are located. Students in Modern Physics Laboratory were engaged in research on metamaterials, holographic data storage, atoms, quantum, nuclear, solid state, and elementary particle physics. The main target of the laboratory followed by professionals in the field of contemporary research topics is to attract the attention of students in cooperation with schools.

Optics and some projects are carried out in the Modern Physics Laboratory:

- 3D Visualization for "Augmented Reality" Design Glass,
- Dissimilar Metals between Quantum Tunneling,
- Generated Using Holographic Data Storage Computer,
- Microwave Metamaterial with Q-Factor Improvement,
- Noise Analysis with pentacene transistors.

Modern Physics Laboratory has the following devices:

- Newport vibration-isolated optical breadboards,
- Helium-neon, argon-ion and Solid-State Lasers,
- Scintillation Detector Multi-Channel Scalar/Analysis,
- Computer Controlled X-Ray System,
- Easy scan Scanning Tunneling Microscope,
- Microwave Generation and Measurement Apparatus.

CAD Laboratory with a complex mechanism such as a heart pumping device simulation engages in technological design and engineering studies. Engineering software packages, including Autodesk products, mainly used in architectural design, which makes it possible for laboratories to use them. Some of the projects carried out in the Computer Aided Design Laboratory are:

- Underwater Life Design (Ocean Life of materials, pressure and toxicity studies),
- Multipurpose Design and Installation,
- Solar Tools,
- DNA Modeling,
- Flight Simulation Test,
- Artificial Body Parts and Body Design and Simulation,
- Clean slate of innovative mounting the Screen Auto Car Lift Robot.

The following equipment and software are used in the laboratory:

- The HP Compaq dc5100 Micro-tower,
- Intel Pentium 4 HT/2.8 GHz, 1 GB RAM,
- NVIDIA Quadro NVS 280 Graphics Adapter,
- Blaster Audigy X-Fi Audio Midi Interface,
- Design Jet 500 plotters,
- Z 310 3-D prototyping plotter machine,
- Inventor, AutoCAD Mechanical, Civil, Land, Revit, VIZ, and 3ds Max Solid Works CAD Software.

TUBITAK 4006 Science Fair Support Program

In accordance with the protocol signed between the MoNE and TUBITAK, the program was established to develop the scientific culture of our country (The Scientific and Technological Research Council Of Turkey, 2015). Within the framework of the school curriculum, students have been studying courses and making

research on the issues that they have identified by their own interests, so that they can share the results of their research. Therefore, the program needs to include following items to create an environment where the learning is fun for all:

- Encourage the adoption of science and scientific work by the new generations,
- To link the science to everyday life,
- To develop research techniques and scientific reporting as well as to distribute the scientific presentations in order to improve young people's skills,
- To provide an opportunity for every child in different science projects and cognitive developmental level,
- To create new environments and opportunities for students to do research projects and sharing,
- To introduce entertaining and interesting part of the science to students to eliminate the pressure of competition on students,
- To ensure equal access for scientific projects to school districts in different socioeconomic levels,
- To teach how to adapt the science and solutions to real-life problems.

Science Fair will be held in the year 2015 in 3,300 schools.

4007 TUBITAK Science Fair Support Program

The aim of this program was to provide science communication, to spread scientific knowledge to a broader community, to raise the interaction of science and technology for public, and to comprehend exhibitions, stage shows, performances, workshops/laboratory work, thematic science games, contests, interviews and so on (The Scientific and Technological Research Council Of Turkey, 2015). Providing the participants the fundamental scientific facts through these events, it was aimed to trigger curiosity and desire to learn, research, and inquiry. In 2014, TUBITAK decided to support 25 projects with an upper limit of 100,000 Turkish Liras as grant per project.

TUBITAK 5000 Open Source Digital Content Support Program

The overall objective of the program is to accelerate the creation of high quality e-books and e-courses for K-12, so that equal opportunities for all students can be provided (The Scientific and Technological Research Council Of Turkey, 2015).

Conclusion

In Turkey, public and private science high schools contribute to the actualization of 2023 targets by submitting qualified students to universities. For a better quality, the following suggestions should be considered. Curriculum needs to be changed to accelerate the transition from industrial society to the information society, so individuals should be trained for future technologies and professions. Laboratories in STEM High Schools should be updated. Physical conditions of high schools should be improved to the best level. Cooperation between alumni, students, parents, and schools should be strengthened.

There should be cooperation between universities and schools for K-12 such as METU and Ankara Science High School. Freedom in decision-making and implementation should be provided to the science high schools. Science high school teacher selection should be rearranged according to much more objective principles (McKinsey & McKinsey, 2007). Master of philosophy and doctorate in teacher appointments and knowledge of foreign languages should be set as prerequisites. In-service training for teachers should be permanent, teachers' knowledge and experience should be enhanced, and teachers should go to abroad, so that they can be up to date about new developments in the world. Alumni's opinions should be obtained to understand whether their education was sufficient for the university that they attended. More resources and new programs must be devoted to public and private science high schools.

References

Achive (2013, November). *All standards, all students: Making the next generation science standards accessible to all students*. Retrieved from http://www.nextgenscience.org/sites/ngss/files/NGSS%20DCI%20Combined%2011.6.13.pdf

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Corlu, M. S., Öner, T., & Özdemir, S. (2015). STEM eğitimi Türkiye raporu: Günün modası mı yoksa gereksinim mi? [A report on STEM Education in Turkey: A provisional agenda or a necessity?][White Paper]. İstanbul, Turkey: Aydın Üniversitesi. *İstanbul Aydın Üniversitesi STEM Merkezi ve Eğitim Fakültesi*.

Bybee, R. W. (2010). What is STEM education?. *Science, 329*(5995), 996-996.

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

Daeschner, S. W. (1965). Review of the physical science study committee high school physic course. Retrieved from https://archive.org/details/reviewofphysical00daes

Erdogan, N., & Stuessy, C. L. (2015a). Modeling successful STEM high schools in the United States: An ecology framework. *International Journal of Education in Mathematics, Science and Technology, 3*(1), 77-92.

Erdogan, N., & Stuessy, C. L. (2015b). Examining inclusive STEM schools' role in the college and career readiness of students in the United States: A multi-group analysis of students' achievement outcomes. *Educational Sciences: Theory & Practice, 15*(6), 1517-1529.

McKinsey, C., & McKinsey, M. M. (2007). *How the world's best performing school systems come out on top.* Retrieved from http://www.smhc-cpre.org/wp-content/uploads/2008/07/how-the-worlds-best-performing-school-systems-come-out-on-top-sept-072.pdf

McInerney, J. D. (1986). *Curriculum development at the biological sciences curriculum study.* Retrieved from http://www.ascd.org/ASCD/pdf/journals/ed_lead/el_198612_mcinerney.pdf

Ministry of National Education. (1993). *Journal of regulations* (No: 2385). Ankara, Turkey.

National Research Council. (1996). *National science education standards*. Retrieved from http://www.nationalacademies.org/nrc/

National Science Teachers Association. (2014). *Access the next generation science standards by disciplinary core ideas*. Retrieved from http://ngss.nsta.org/AccessStandardsByDCI.aspx

Regulation on Science High School. (1975). *TR official journal* (No: 15209). Ankara, Turkey.

Saritha, R. (2014). *Chemical education material study*. Retrieved from http://www.slideshare.net/sarithaspr/chemical-education-material-study

School Mathematics Study Group. (1958-1977). A guide to the school mathematics study group records. Retrieved from http://www.lib.utexas.edu/taro/utcah/00284/cah-00284.html

The Bronx High School of Science (2016). *About*. Retrieved from http://www.bxscience.edu/

The Scientific and Technological Research Council Of Turkey. (2015). *Science and society*. Retrieved from http://www.tubitak.gov.tr/en

Virginia Thomas Jefferson Science and Technology High School. (2015). *Research labs*. Retrieved from https://www.tjhsst.edu/research-academics/research-labs/index.html

Zabun, B. (2007). *Ankara science high school 1964-2004 monography* (Unpublished doctoral dissertation). Gazi University, Ankara.