



THE STATE OF THE ART ANALYZE ABOUT STEM EDUCATION PRACTICES IN TÜRKİYE

WP 2: State of the art analyze and joint strategy development about Green STEM education practices

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Forefront

This report presents a comprehensive overview of the Turkish STEM Initiatives, compiled by a team of researchers with expertise in the fields of STEM Education and STEM fields.

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Eylem BAYIR has been working as Prof. Dr. at Trakya University in Science Education Department and as head of the department since 2015. Her fields of research is STEM education, inquiry-based science learning, nature of science, educational games on science, professional development of science teachers. She has many national and international projects, articles and book chapters on these subjects. She was the coordinator of “Bridge from Türkiye to the World: STEM Education” project carried out with the support of the Turkish Cooperation and Coordination Agency –TIKA. She provided STEM training for teachers from seven different countries from Asia and Balkans in 2018 and 2019 in this project with her colleagues.

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Assoc. Professor Dr. Hüsnüye Durmaz

Dr. Hüsnüye Durmaz, an associate professor and full-time researcher at Trakya University, is passionate about promoting STEM education and socio-scientific issues. His research focuses on improving science education by enhancing the professional development of science teachers



and integrating innovative technologies into their lessons. He also develops hands-on and inquiry-based STEM activities for elementary and middle school students, and conducts professional development programs for teachers. Dr. Durmaz's work is essential for improving the quality of STEM education and inspiring the next generation of scientists, engineers, and innovators.

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Assist. Professor Dr. EmrahOğuzhanDinçer

Dr. Emrah OĞUZHAN DİNÇER is a full-time assistant professor at Trakya University who is actively engaged in researching the integration of science, mathematics, and physics teaching. Her primary focus is on assisting science teachers in incorporating technology-based teaching methodologies into their lesson plans. With a background in mechanical engineering, Dr. OĞUZHAN is well-equipped to design and implement STEM activities suitable for middle school students.

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Dr. Sertaç Arabacıoğlu, a full-time assistant professor at Trakya University, is actively involved in promoting STEM education through various research and outreach activities. One of Dr. Arabacıoğlu's main areas of research is the continuing professional development of science teachers. He understands that teachers play a critical role in shaping students' attitudes and interests towards STEM subjects. Dr. Arabacıoğlu is also involved in the development of STEM



activities for elementary and middle school students. These activities are designed to be hands-on and inquiry-based, allowing students to explore and learn about scientific concepts in a fun and interactive way. Additionally, he organizes professional development programs for teachers, including guided teacher camps and interactive workshops. These programs enable teachers to learn new teaching techniques and share best practices with their colleagues.

Our team studied the various sources of information available to provide an in-depth analysis of the current state of STEM initiatives in Türkiye. Thus, the first step in preparing a Turkish STEM Initiatives Country Report was to identify the sources of data. And we decided various sources, including government-funded, university-led, and industry-led organizations. Additionally, we've consulted research papers published in journals indexed by Web of Science (WoS) and Türkiye (TR), as well as master's and PhD theses. We also considered STEM activity workshops, such as those held at STEM centers, science museums, and interactive exhibits.

We analyzed to identify trends and patterns, as well as challenges and opportunities in Turkish STEM initiatives by looking for common themes and patterns in the last 5th years data. The first section of the report aimed to provide a calibrated perspective on STEM education within the consortium by presenting a general approach to STEM education and reflecting the partner country's understanding of STEM education through methods and activities. The second section provides a comprehensive analysis of research reports, articles, theses, and other science and society activities related to STEM education. Finally, an overview on the challenges and opportunities awaiting the project stakeholders is presented. We hope that this report will be a valuable resource for those interested in understanding the current state of STEM initiatives in Türkiye.

Project Coordinator

Prof. Dr. Eylem BAYIR



Index of abbreviations

Ministry of National Education (Türkiye)	MEB
Turkish Scientific and Technical Research Council	TÜBİTAK
Turkish Industry and Business Association	TUSIAD
Ministry of Development	KB
Science, technology, engineering, and math	STEM
İstanbul Aydın University (Private University)	IAU
Programme for International Student Assessment	tpacktpack
Technological Pedagogical Content Knowledge	TPACK
Information and Communication Technology	ICT



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STATE-OF-THE-ART STEM EDUCATION INITIATIVES IN TÜRKİYE

Foundational Sources and National Context for Country Report Coverage

To foster a skilled workforce and spur economic growth, STEM education has been recognized as a crucial field of focus. In order to gain insight into the present status of STEM education in Türkiye, we have compiled information from several sources (refer to Table 1), which encompass reports from government-funded, university-led, and industry-led organizations. Moreover, we have scrutinized research papers published in journals listed in Web of Science (WoS) and Türkiye (TR) to discern patterns and trends in STEM education. We have also evaluated master's and PhD theses to gain a more profound understanding of the research in this domain. Finally, we have analyzed STEM activity workshops such as STEM centers and STEM-related interactive exhibits and workshops in Science Centers and Museums to fathom the practical experiences that are being offered to students. By combining these diverse data sources, our objective was to provide a comprehensive comprehension of STEM education in Türkiye and to identify possible areas for improvement.

Table 1.
Source of data for Country Report

Sources	Number of sources
Reports	
Government-funded	7
University-led	2
Industry-led	2
Published Papers from Journals	
WoS indexed studies from Turkey Country/Region	129
TR indexed studies from Turkey Country/Region	104
Master's and PhD Thesis	230
STEM centers and workshops	
STEM centers	13
STEM-related interactive exhibits and workshops in Science Centers and Museums	7



Reports Laying the Foundations for the Implementation and Dissemination of the STEM Approach in Türkiye

Today, it is known by everyone that science, technology, mathematics and engineering constitute the main components of the development of countries. For this reason, many countries are investing in the STEM approach, which enables future generations to grow up in these areas. In this context, some reports/documents have been prepared by MEB as the institution responsible for education, laying the foundations for the implementation and dissemination of the STEM approach in Türkiye. With the prepared reports/documents, the necessity of STEM education has been revealed by the education experts and institutions and the business world, and Türkiye's need for this approach has been brought to the agenda.

In the "Vision 2023 Strategy Document", prepared in 2004, it was stated that "Developing the creativity and imagination of the individual; observing and evaluating individual differences, each individual can develop himself at the highest level in line with his characteristics; freed from time and space constraints, created his own unique learning technologies and renewed himself with the flexibility of change. The vision in the field of education is "to have a learning and people-oriented education system that has the power to learn". At the same time, being able to dominate the technologies of the future and the fields of science that supports these technologies requires having trained manpower; and this manpower includes R&D personnel and people who have received science and engineering education in the aforementioned science and technology fields; therefore, it was stated that all levels of the education system should be taken into account in order to train people with these characteristics (Turkish Scientific and Technical Research Council [TÜBİTAK], 2004).

In 2010, "Science and Technology Human Resources Strategy Document" was published by Scientific and Technological Research Institution of Türkiye (TUBİTAK) and this document includes adding project-oriented science and technology trainings to the curriculum in primary and secondary education, increasing curiosity, raising creative and entrepreneurial mindsets; Some strategies have been determined, such as increasing the interest in scientific activities by increasing popular science activities for primary and secondary education, adding projects and popular science subjects to the curriculum of the education faculty, and disseminating R&D project competitions among primary and secondary school students (TUBİTAK, 2010).

"The Tenth Development Plan" published in 2013 is the twenty-first century; it is pointed out that it will be the century of countries that can produce new knowledge by using global knowledge, transform knowledge into economic and social benefits, integrate this process with information and communication technologies, and adopt a human-oriented development approach, in addition to raising qualified human power. In this plan, the main purpose of the education system is; It is stated that it is the training of productive and happy individuals who have developed thinking, perception and problem solving skills, have self-confidence and sense of responsibility, entrepreneurship and innovation, are prone to the use and production of



science and technology, equipped with the basic knowledge and skills required by the information society (Ministry of Development[KB], 2013).

In the report titled "Demand and Expectations Research for STEM-Educated Workforce" published by the Turkish Industry and Business Association (TUSIAD) in 2014, the critical role of STEM education in the economic and technological development of countries was emphasized, and in the future, STEM education, that is, different disciplines combined. It is revealed that learned brains will be needed in the whole. It has been determined that there are differences in the contributions of those who graduated from STEM fields and those who graduated from other fields in companies. As a result of the report, it was stated that it is of great importance to make necessary reforms in the curriculum, education methods and teacher training in order to raise individuals who think creatively, innovatively, analytically and critically, and have high problem-solving skills, and that it is necessary to aim to increase STEM skills at all levels of the education system (TUSIAD, 2014).

Regarding STEM education, MEB has been involved as a national support point in the Scientix Project (the community project for science education in Europe) carried out by the European Schoolnet since 2014. Within the scope of this project, Europe-wide collaboration between STEM (science, technology, engineering and mathematics) teachers, education researchers, policy makers and other STEM education professionals is encouraged and supported. The project aims to disseminate the use of technology and good practices in science education in Europe with the teacher communities created.

The first report in Türkiye, which is one of the studies carried out for the dissemination of STEM education outside MEB, is the "STEM Education Türkiye Report" prepared in 2015 hosted by Istanbul Aydın University. In the report, the need for STEM education in Türkiye has been revealed and suggestions have been made by determining a road map for its implementation (Akgündüz et al., 2015).

With the "2015-2019 Strategic Plan" published by MEB in 2015, it started with studies on STEM education in Türkiye. It is stated in the plan that it is aimed to raise individuals who are creative, entrepreneurial, innovative, open to communication and learning, self-confident and responsible by gaining the knowledge, skills, attitudes and behaviors required by the age. In the plan, MEB has paved the way for the integration of STEM education into our education system by including strategic objectives that reveal the necessity of using STEM education, thus, studies on STEM education throughout the country have accelerated (MEB, 2015).

In 2016, MEB published the STEM education report, and an action plan was prepared that includes the issues that need to be done in order to integrate this approach into the Turkish education system and to spread it throughout the country by revealing the situation regarding STEM education. The STEM Education Action Plan was formed from the following steps: 1. Establishment of STEM Education centers, 2. Conducting STEM education research in cooperation with universities in these centers, 3. Training teachers to adopt the STEM education approach, 4. Updating the curriculum to include STEM education, 5. Creating teaching environments and providing course materials for STEM education. The report has a critical importance in the adoption and dissemination of the STEM education approach in our



country. As a matter of fact, STEM education started with the Science Curriculum published by MEB in 2018. In the Science Curriculum, starting from the 4th grade, the component "Science, engineering and entrepreneurship practices" has been included in order for students to establish the connection between engineering and science and to understand the interdisciplinary interaction (MEB, 2018).

The critical role of STEM fields was also mentioned in the report titled "STEM Needs in Türkiye Towards 2023" prepared by PwC and TUSIAD in 2017, and the 'savior abilities' of the 21st century (critical thinking and problem solving, entrepreneurship and developing cooperation between systems and people, taking initiative, effective oral and written communication, analytical skills, continuous learning, curiosity and creativity) will increase. In the report, it was emphasized that the steps required for the development of STEM education and STEM workforce should be addressed at the national policy level and supported by the public, action plans should be implemented with the cooperation of the public, education and business world, and the progress should be followed closely.

In the "2023 Education Vision" document published by MEB in 2018, it is planned to establish STEM workshops within the scope of "Design-Skill Workshops" in all schools for the development of children's interests, talents and temperaments. These workshops are defined as "workshops where activities aiming at transforming theoretical knowledge into practice, product and innovative inventions, enabling students to see the information they learn in science, technology, engineering and mathematics courses as parts of a whole" (MEB, 2018).

In the "Integration of STEM Education into Curriculum: Workshop Report" prepared as a result of the "Workshop on the Integration of STEM Education into the Curriculum" hosted by Istanbul Aydın University in 2018, the problems raised by teachers, experts and academics regarding the integration of STEM education into the curriculum were identified and the problems were divided into 11 themes. has been collected. Suggestions for solutions to the examined problems; It is necessary to determine a state education policy for STEM education, to carry out awareness activities, to design a curriculum that focuses on the skills and process suitable for STEM education, to train teachers who will implement this program in education faculties, to increase the competencies of current teachers and to create the necessary physical, social and managerial infrastructure for STEM education. has been revealed. In the "Integration of STEM Education into Curriculum: Workshop Report" prepared as a result of the "Workshop on the Integration of STEM Education into the Curriculum" hosted by Istanbul Aydın University in 2018, the problems raised by teachers, experts and academics regarding the integration of STEM education into the curriculum were identified and the problems were divided into 11 themes. has been collected. Suggestions for solutions to the examined problems; It is necessary to determine a state education policy for STEM education, to carry out awareness activities, to design a curriculum that focuses on the skills and process suitable for STEM education, to train teachers who will implement this program in education faculties, to increase the competencies of current teachers and to create the necessary physical, social and managerial infrastructure for STEM education.



Table 2

Reports Laying the Foundations for the Implementation and Dissemination of the STEM Approach in Turkey

Date	Report Name	Institution Name	Emphasis on STEM Education in the Report
2004	Vision 2023 Strategy Document	TUBİTAK	As a vision in the field of education; developing the creativity and imagination of the individual; by observing and evaluating individual differences, each individual can develop himself at the highest level in line with his characteristics; freed from the constraints of time and space, it has created its own unique learning technologies and has the power to renew itself with its flexibility of change; It has been determined to have a learning and people-oriented education system.
2010	Science Technology Human Resources Strategy Document	TUBİTAK	Some strategies have been determined, such as adding project-oriented Science and Technology education to the curriculum in primary and secondary education, increasing the interest in scientific activities, making projects and adding popular science subjects to the curriculum of the education faculty, and disseminating R&D project competitions between primary and secondary school students.
2013	Tenth Development Plan	Ministry of Development	The main purpose of the education system; It is stated that it is the training of productive and happy individuals who have developed thinking, perception and problem-solving skills, have self-confidence and sense of responsibility, entrepreneurship and innovation, are prone to the use and production of science and technology, equipped with the basic knowledge and skills required by the information society.
2014	Demand and Expectations Research for STEM-Educated Workforce	TUSİAD	It has been stated that it is of great importance to make necessary reforms in the curriculum, education methods and teacher training in order to raise individuals who think creatively, innovatively, analytically and critically, and have high problem-solving skills in the education system, and it is necessary to aim to increase STEM skills at all levels of the education system.
2014	Scientix Project	MEB	The project encourages and supports Europe-wide collaboration between STEM (science, technology, engineering and mathematics) teachers, education researchers, policy makers and other STEM education professionals. The project aims to disseminate the use of technology and good practices in science education in Europe with the teacher communities created.



Table 2. Continue

Reports Laying the Foundations for the Implementation and Dissemination of the STEM Approach in Turkey

Date	Report Name	Institution Name	Emphasis on STEM Education in the Report
2015	2015-2019 Strategic Plan	MEB	It is stated in the plan that it is aimed to raise individuals who are entrepreneurial, innovative, creative, open to communication and learning, self-confident and responsible by gaining the knowledge, skills, attitudes and behaviors required by the age.
2015	STEM Education Turkey Report	IAU	In the report, the need for STEM education in Turkey has been revealed and suggestions have been made by determining the road map for its implementation.
2016	STEM Education Report	MEB	The situation regarding STEM education in our country has been revealed, and a STEM Education Action Plan has been presented in order to integrate STEM education into the education system in Turkey.
2017	Towards 2023 STEM Requirements in Turkey Report	PwC & TUSIAD	The critical role of STEM fields was mentioned, and it was emphasized that the steps required for the development of STEM education and STEM workforce should be addressed at the national policy level and supported by the public, action plans should be implemented with the cooperation of the public, education and business world, and progress should be followed closely.
2018	2023 Education Vision	MEB	It is planned to establish STEM workshops within the scope of "Design-Skill Workshops" in all schools for the development of children's interests, talents and temperaments.
2018	Integration of STEM Education into the Curriculum: Workshop Report	IAU	Problems raised regarding the integration of STEM education into the curriculum have been identified and solutions have been proposed for the problems examined.



Situation of STEM Approach in Curriculums in Türkiye

Compared to PISA 2015, Türkiye significantly increased its performance in all three areas (reading skills, mathematical literacy, science literacy) in PISA 2018 (MEB, 2019). Despite this increase, it does not rank high enough. It is possible to say that it is important for Türkiye to reach the desired level in the international PISA exams by adopting the STEM approach and integrating it into the curriculum.

Integrating STEM into curricula at all levels from pre-school to university is of great importance for the spread of STEM. STEM-integrated curricula will enable students to use different disciplines together to solve problems encountered in daily life, enabling meaningful learning to take place (Aydeniz, 2017; Beane, 1995; Czerniak, Weber, Gonzalez & Kuenzi, 1999; Czerniak, et al., 1999; Yıldırım & Altun, 2015).

From this point of view, as it can be understood from what is explained below, studies have started and are continuing with the integration of the STEM approach into the curricula at all education levels in Türkiye.

Situation of STEM Approach in Preschool Curriculum:

The current program as a pre-school education program in Türkiye is the 2013 Pre-School Education Program prepared in 2013. Although there is no direct emphasis on STEM education in this program, the achievements and indicators belonging to all development areas, primarily the acquisitions and indicators related to cognitive development, can be easily associated with STEM education. It has been revealed that the achievements in the Education Program are related, include basic ideas and concepts related to STEM education, and have most of the features of STEM education (AtaDemircan, Şenyurt, & Çetin, 2017). In this respect, the program is suitable for STEM education.

It is also known that MEB, private education institutions and universities and NGOs carry out educational activities, fairs, competitions, curriculum development and implementation activities regarding the STEM approach in pre-school education in Türkiye (Polat and Bardak, 2019).

Some universities in Türkiye (such as METU, YÜ, Bahçeşehir) organize trainings for preschool teachers such as STEM Workshop, STEM Trainer's Education Program, Early Childhood STEM Education, and it is aimed to raise awareness in preschool teachers and to have knowledge about practices.

Situation of STEM Approach in Primary/Middle School Curriculum:

The regulations regarding the integration of the STEM approach in the curricula in Türkiye are particularly striking in the science curriculum.



Although not under the name of STEM approach in the Science and Technology Curriculum prepared in Türkiye in 2005, the existence of issues such as "Science-Technology-Society-Environment Relationship", "Technological Design Cycle and Entrepreneurship" can be considered as a start for the implementation of the STEM approach.

In the "STEM Education Report" prepared by MEB in 2016, the necessity of STEM education was emphasized in the curriculum, and this emphasis was included in the report as follows: The examination system should be shaped accordingly, and students' high-level skills such as questioning, research, product development and invention should be highlighted. Science laboratories in schools should be reorganized and provided in accordance with STEM education." (MEB, 2016). In the classrooms, STEM applications were included as the last unit, under the name of "Applied Science", accompanied by the achievements that correspond to the steps of the engineering design process.

With the update made in the Science Curriculum in 2018, it was shown that the STEM approach was adopted by giving the "Science, Engineering and Entrepreneurship Practices" as covering all the units, although the name "STEM" was not clearly stated. In addition, the explanation regarding the application of the STEM approach in the program is as follows: "Within the scope of Science, Engineering and Entrepreneurship Applications in the program, first of all, students are expected to define a daily need or problem related to the topics covered in the units. It is desired that the problem is aimed at improving the tools, objects or systems used or encountered in daily life. In addition, the problems should be handled within the scope of material, time and cost criteria. In solving the problem, students compare alternative solutions and choose the appropriate one within the scope of the criteria. By planning for the chosen solution, they are expected to present and present the product at the next stage. The design and production process of the product is carried out in the school environment. Students are expected to make experiments during the product development phase, record the qualitative and quantitative data they have obtained as a result of these trials, and evaluate them with their ability to read or create graphs. They are asked to create strategies and use promotional tools to market the product in order to develop entrepreneurial skills. For example, students can prepare newspaper, internet, television advertisements or shoot short films for promotional purposes." (MEB 2018).

Situation of STEM Approach in Secondary School Curriculum:

Although STEM approach is not mentioned at all in the education programs of STEM courses (Physics, Chemistry, Biology, Mathematics and Computer Science), it has been determined that the applications of the STEM approach are either not included in the purchases or they are given little or no place (Karabolat, Atıcı & Taflı) , 2021; curriculum.meb.gov.tr).

Status in the University/Faculty of Education Curriculum:



The support and contributions of universities in Türkiye towards the implementation of the STEM approach have been increasing in recent years. Within the scope of this context, universities conduct various activities such as arranging trainers' trainings via application and research centers, integrating compulsory or optional STEM courses into their curricula, organizing symposiums, congresses, and workshops, as well as undertaking diverse scientific studies and projects (MEB, 2016). The links provided below offer noteworthy instances of these activities:

- 4th International STEM Education Conference: <https://www.stempd.net/>
- Hacettepe STEM & Maker Lab: <https://hstem.hacettepe.edu.tr>
- BİLTEM Center for Science Technology Engineering and Mathematics Education: <https://biltemm.metu.edu.tr/tr>
- Muğla Sıtkı Koçman University Science Education Research & Application Center <https://mubem.mu.edu.tr/tr>

Especially education faculties have an important place because they train teachers who will apply the STEM approach, and the teachers who are responsible for applying the STEM education approach provide academic support through in-service training. It is absolutely necessary to include courses in the curricula of education faculties that will enable teacher candidates to be trained to have STEM-related field knowledge, field education knowledge, and STEM application competencies.

In Türkiye, education faculties undergraduate curricula were updated in 2018, and when the course names and course contents in teacher training undergraduate programs related to STEM fields are examined (Science Education, Elementary Mathematics Teaching, Computer and Instructional Technologies Teaching, Physics Teaching, Chemistry Teaching, Biology Teaching, It is seen that there are no courses related to direct STEM education in the programs (Türk, 2019; yok.gov.tr). However, it has been determined that in the curricula of Science and Primary School Mathematics Teaching departments, there is a course for associating the department field with other fields (Interdisciplinary Science Teaching, Relation in Mathematics Teaching). However, it has been determined that these courses are theoretical courses for 2 or 3 hours.

It is known that no undergraduate or graduate education programs related to STEM have been opened in any education faculties in Türkiye (Çolakoğlu & Günay Gökben, 2017).

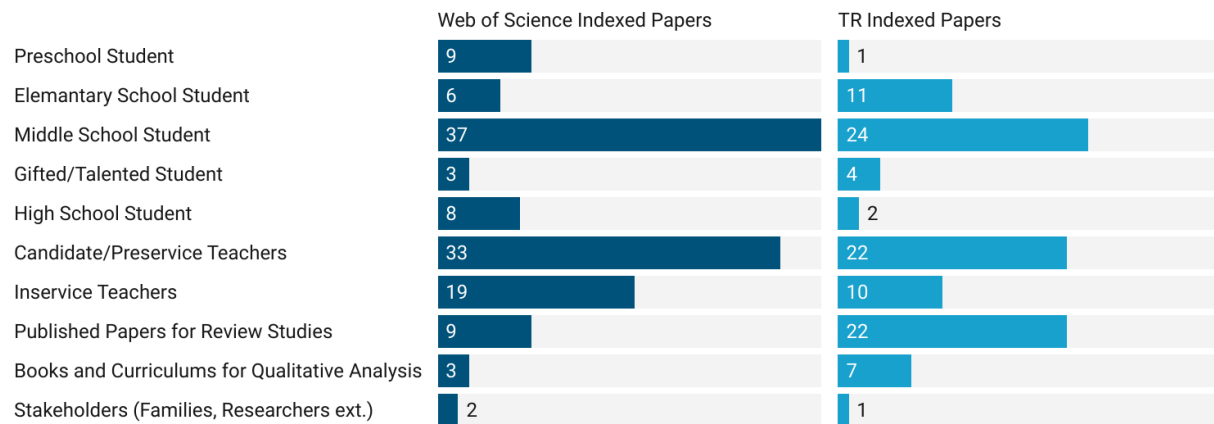
This situation reveals the necessity of opening courses that are directly related to STEM education and including applications in undergraduate programs of education faculties, as well as postgraduate education programs and designing curricula for these courses.



State-of-the Art Research Initiatives in the Web of Science (WoS) and TR-Indexed Papers

In this analysis, we examined 226 papers on STEM education that were indexed in WoS and TR. Our extraction criteria involved searching for articles that were conducted in Turkish universities, schools, and other institutions. We collected all the relevant papers related to STEM education trends in Türkiye from WoS and TR indexed sources to ensure that the data was comprehensive and inclusive. Other scopes were excluded. Next, we organized the collected papers by creating a spreadsheet or database that contained important details such as the title, purpose, methodologies, participants, and results of each paper. This step may have required data cleaning and formatting to ensure consistency. We also carried out necessary transformations to standardize the coding structure. To analyze the data, we identified patterns, trends, and relationships among the papers. This involved summarizing the key findings of each paper and categorizing them into relevant codes or categories. Figure 1 summarizes the sources of data and participants of the published papers analyzed in the country report.

Participant/data source-based categorization of examined publications from two indexes



Note. The International Standard Classification of Education (ISCED) system, recognized by the United Nations Educational, Scientific, and Cultural Organization (UNESCO), classifies education as preschool, elementary, middle, and high school students, which are used to categorize different school levels in studies. It is important to consider that a study may involve multiple groups of participants.

Figure 1.
Sources of Data & Participants of Published Papers Analyzed in Country Report

Figure 2 depicts the analyzed papers and their respective methodologies that were indexed.



Methodology-based categorization of examined publications from two indexes

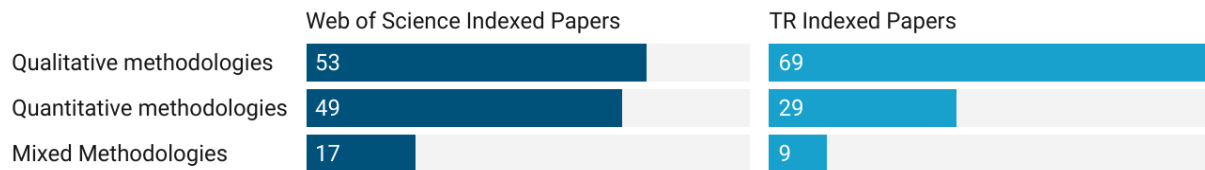


Figure 2.

Methodologies of Published Papers Analyzed in Country Report

The study involved various groups of participants, including students and teachers, and analyzed 226 articles indexed in WoS and TR that explored STEM education trends in Türkiye. The findings, presented through descriptive patterns for each participant group, offer insights into the different approaches to STEM education in the country.

Research Trends and Patterns Involving Student Participation: Sampling from Preschool, elementary, middle, and high schools

Studies with preschool students:

According to the state-of-the-art studies, early exposure to **STEM activities** can help children develop an interest in science, technology, engineering, and math, which can inspire them to pursue careers in these fields in the future and help them develop a better understanding of engineering concepts (Akpınar & Akgunduz, 2022). Furthermore, **STEM activities** often involve problem-solving, which can help preschoolers develop critical thinking skills and learn how to approach challenges in a logical and systematic way (Bapoğlu Dümenci et al., 2021; Malcok & Ceylan, 2022). In addition, **STEM activities** can also encourage creativity and innovation, as children explore different solutions to problems and use their imagination to design and build things (Uret & Ceylan, 2021). Thus, studies emphasize the significance of incorporating **design thinking** in STEM education for preschoolers to stimulate the development of 21st century skills (Yalcin, 2022).

Studies also give a better understanding about the perspectives and experiences of preschoolers. For example, studies have emphasized the importance of comprehending preschoolers' viewpoints and encounters regarding **engineering design-oriented STEM tasks** concerning the concepts of science, like forces, floating/sinking (Ata-Akturk, 2023), as well as images of **engineers and engineering** (Ata-Akturk & Demircan, 2022). In addition, educators and researchers have reported their observations from particular **STEM activities** in a more comprehensive manner, including but not limited to, egg-carrying without breakage (Ultay &



Aktas, 2020), the realm of machinery (Abanoz & Yabas, 2022), and Makey-Makey programming and robotics activities (Tanik Onal & Saylan Kirmizigul, 2022).

Studies with elementary students:

Various studies have been conducted on elementary school students, resulting in different research outcomes. For instance, Akar and Yadigaroğlu (2021), Bircan and Calisici (2022), Yetkin and Aküzüm (2022), and Pekmez et al. (2018) focused on **the impact of STEM activities** on students' attitudes towards STEM, related skills, and academic achievements. Moreover, Cetin et al., (2020) researched young children's preferences on STEM activities based on gender, whereas another group of studies examined **students' creativity, career choices, and perceptions of engineers and engineering**, such as Azgın and Şenler (2019), Çil and Özlen (2019), and Gülhan and Şahin (2018). Sisman et al. (2021) investigated the effectiveness of robotics training on **children's spatial ability** and attitude towards STEM, and various approaches were also examined, including **out-of-school STEM workshops** (Timur et al., 2020), STEM activities in free activity course (Yaşlık & Akçay, 2022), **biomimicry-based STEM activities** (Savran Gencer et al., 2020), **Ethno-STEM Approach** (Basaran & Erol, 2023), and **aesthetics in nature through STEM and STEAM education** (Reffiane et al., 2021), all of which were aimed at elementary school students.

Studies with middle school students:

Upon analyzing the state of the art of STEM studies conducted with middle school students in TÜRKİYE, it becomes evident that various activities could incite STEM education in diverse manners. For example, STEM activities in schools allow students to **develop a range of views and attitudes towards in science, technology, engineering, and math** (Akçapınar & Coşgun, 2019; Ayaz et al., 2020; Aydın & Karslı, 2019; Ceylan & Karahan, 2021; Dönmez, 2020; Ertem Akbaş et al., 2019; Pişkin Tunç & Gündoğdu, 2022). By engaging in STEM activities, students can **develop a deeper interest and understanding of STEM fields** and can be inspired to pursue further studies in these areas (Dedetürk et al., 2021; Higde & Aktamis, 2022; Özcan & Koca, 2019; Tozlu et al., 2019). These activities often involved inquiry-based, project-based learning and problem-solving, which can help to build critical thinking and analytical skills (Bahşi & Açıkgül Fırat, 2020; Celik, 2022; Gülen & Yaman, 2018; Higde & Aktamis, 2022; Nağaç & Kalaycı, 2021).

Moreover, **Design-based STEM education studies** emphasize the use of design processes to develop solutions to real-world problems. By engaging in design activities, students can **develop critical thinking and creativity skills, entrepreneurship and career choices and interest** (Delen & Sen, 2023; Gencer & Dogan, 2020; Kirkic & Uludag, 2021; Meral & Altun Yalçın, 2022; Sarıgül & Çınar, 2021; Savran Gencer & Doğan, 2020; Yazici et al., 2022). The use of **technology and tools like 3D printers** can help to make the design and engineering process more engaging and accessible to students (Sen et al., 2020). Furthermore, **Engineering-oriented**



STEM activities also allow students to explore concepts related to civil, mechanical, and electrical engineering(Aydogan & Cakiroglu, 2022; Johnston et al., 2019). By **engaging in engineering activities**,middle school students can develop skills in problem-solving, critical and computational thinking, and creativity(Ergun & Balcin, 2019; Ince & Koc, 2021). These skills are essential for interest in many STEM fields, including engineering, architecture, and construction(Balcin & Ergun, 2019; Ozkul & Ozden, 2020).

The studies on robotics, as well as coding and programing education provides hands-on learning opportunities for students to explore engineering and programming concepts(Akkaş et al., 2020;Cakir & Guven, 2019; Korkmaz et al., 2019). By engaging in STEM robotics activities, students can **develop skills in coding, mechanical engineering, and electronics, as well as perception, creativity and attitudes**(Adsay et al., 2020;Bolatlı& Korucu, 2018;Guven et al., 2022; Kutlu & Bakırcı, 2022; Ucgul & Altıok, 2022). These skills are essential for interest in many STEM career, including robotics, automation, and manufacturing.Furthermore, **game-based STEM design activities**with middle school students could help to promote interest in computer science and programming(Cakir et al., 2021). By engaging in game design, students could**develop skills in coding, storytelling, visual design and also deeper understanding on science topics**(Hacıoglu & Donmez Usta, 2020). These skills are essential for many STEM fields, including game development, virtual reality, and graphic design.

STEM-based environmental activities can help to promote interest in environmental science and sustainability. By engaging in these activities, students can develop skills in biology, chemistry, and environmental engineering(Erkol et al., 2022; Öztürk&Özdemir, 2020; Uslu & Yaman, 2021). **Biomimicry activities** allow students to explore how natural systems can inspire engineering solutions to real-world problems(CanbazogluBilici et al., 2021; Gencer et al., 2020). Additionally, **out-of-School STEM Education Studies and Programs** provide opportunities for students to explore STEM fields outside of traditional classroom settings. These programs, like **robotic camps**,can offer hands-on, project-based activities that foster interest and engagement in STEM fields(Ucgul & Altıok, 2022). By offering exposure to **out-of-schoolSTEM programs**, these programs can help to promote interest in STEM-related careers, motivations and metacognitive awareness(Baran et al., 2019; Çevik & Abdioğlu,2018).

In addition, **studies onSTE(A)M education** emphasizes the integration of arts and design into STEM fields. By engaging in STEAM activities, students can develop creativity, critical thinking, and problem-solving skills(Bati et al., 2018; N. A. Cakir et al., 2021; Ozkan & Topsakal, 2021; Ozkan & Umdü Topsakal, 2021). This interdisciplinary approach can help to promote interest in STEM fields among students who may not have been interested in these subjects before.

Studies with high school students:

High school students have been the subject of numerous studies on STEM education. For instance, Donmez (2021) and Karamustafaoglu & Pektas (2022)conducted studies to investigate how **out-of-school STEM activities** can influence students' career choices and



creative problem-solving skills. These studies often use **inquiry-based or project-based learning environments** to enhance academic achievement and career interests, particularly in **vocational high schools**(Cevik, 2018).

Moreover, other studies have focused on the **engineering design process**(Guvenilir & Olcay, 2019), utilizing students' **engineering skills**(Yuceler et al., 2020), and **innovative technology-supported applications**(Kumas, 2021) at this level. Through such studies, it has been demonstrated that high school students generally have motivation and positive attitudes towards STEM education (Gok, 2021; Kızılay et al., 2019; Yerdelen-damar et al., 2021).

Research Trends and Patterns Involving Preservice Teacher Participation: Sampling from Education Faculties

Preservice teachers play a crucial role in shaping the future of STEM education. To ensure they are well-equipped to teach STEM subjects, studies have been carried out to explore the **effects of various STEM activities on their knowledge, skills, and attitudes**. For instance, studies by Timur and Belek (2020), Yorulmaz and Okulu (2022), and Uğraş and Genç (2018) have focused on the impact of STEM activities on candidates' beliefs and STEM intention. Numerous studies have also been conducted to investigate prospective teachers' **perceptions and awareness of STEM education** (Acar et al., 2020; Akgün & Türel, 2021; Koyunlu Ünlü & Dere, 2019). Another study examined the development of computational thinking skills among preservice teachers (Gunbatar & Bakirci, 2019). Additionally, studies by Çakır and Altun (2021), and Özçakır Sumen and Calisici (2022) shed light on the relationship between STEM activities and academic achievement, problem-solving skills, and STEM awareness. Yildirim and Sidekli (2018), on the other hand, explored the link between STEM activities and self-efficacy and TPACK understanding. Kacan and Sahin, (2018) and Özçakır Sūmen and Çalışıcı, (2019) examined the development of creative thinking and project development skills, while Alan et al., (2019) and Z. Cakir & Yalcin, (2022) studied the impact of STEM activities on lifelong learning and integrated teaching knowledge. Furthermore, studies have also looked into preservice teachers' **behavior towards technology and STEM education**. Gul and Ates (2022), for example, explored the factors that influence preservice teachers' acceptance of technology, while Aciksoz et al., (2020) investigated the relationship between STEM value-expectancy. Studies have focused on understanding **the views and attitudes of candidate teachers towards STEM education** (Hiğde et al., 2020; Yorulmaz & Okulu, 2022), as well as their understanding about STEM practices (Arslanhan & İnaltekin, 2020; Aydın et al., 2021; Üre & Çoramık, 2020). For instance, Ciftci et al., (2022) examined preservice teachers' views on STEM education, while Kartal and Tasdemir, (2021) explored their attitudes towards STEM. Meanwhile, Buyukdede and Tanel (2019) investigated prospective teachers' opinions on the effectiveness of STEM activities.

STEM education has become increasingly important as the job market continues to shift towards careers in **engineering and other design-based fields**. To ensure that students are well-prepared for these careers, it is essential that pre-service teachers are equipped with the



necessary skills to effectively teach STEM subjects. This has led to numerous studies that focus on the impact of different teaching methods on preservice teachers' perceptions of STEM education. For example, Ergun and Kiyici (2019) and Özkızılcık and Betül Cebesoy (2020), as well as Kuvac and Koc (2022), have examined the effect of **design-based applications** on students' perceptions of engineering education and engineering as a profession. Similarly, Guleryuz and Dilber, (2022) have investigated the impact of engaging students in **robotic coding and 3D visualization** on their academic success and interest in STEM careers. Other studies have focused on the effects of STEM-focused practical activities on various skills. (Sari, Celik, et al., 2022) have looked at the impact of **Arduino-based activities** on problem-solving and entrepreneurship skills, while Sari, Pektas, et al., (2022) have investigated the development of **algorithmic thinking skills** through physical computing activities with Arduino in STEM education. Finally, some studies have explored the use of media and technology to enhance STEM education, such as Ata and Cevik's (2020) research on the role of **computational thinking skills** in STEM awareness, and Ciftci and Topcu (2022) investigation of the impact of teaching self-efficacy beliefs in **computational thinking** in a STEM course. Alan et al. (2021) also have examined prospective science teachers' scientific processes while they use **Algodoo in their STEM practices**. These studies collectively demonstrate the value of STEM education and the importance of pre-service teachers being equipped with the necessary skills to effectively teach STEM subjects.

Several **qualitative studies** have been conducted to examine the development of pre-service teachers' knowledge and understanding of STEM education. One group of studies focused on investigating the STEM conceptions of pre-service teachers (Aydin-Gunbatar et al., 2021; Koyunlu Ünlü & Dere, 2018), their pedagogical content knowledge (Aydin-Gunbatar et al., 2020), STEM-focused lesson planning (Altan & Ucuncuoglu, 2019; Bozan & Kaya-capocci, 2022; Ürek & Çoramık, 2020), and views on robotic and STEM-based learning environments (Delen & Uzun, 2018; Tekerek et al., 2023; Yüksel, 2022). Another set of studies aimed to gain a better understanding of the influence of a design-based elective STEM course on pre-service teachers' content knowledge, STEM conceptions, and engineering views (Aydin-Gunbatar et al., 2018), as well as the integration of engineering into STEM lessons (Gunbatar et al., 2022; Kınık Topalsan, 2018; Tekerek & Tekerek, 2018). Additional studies explored the use of virtual reality technologies in STEM education through the perceptions of ICT pre-service teachers (Coban et al., 2020), and a redesigned online ICT course using TPACK for STEM pre-service teachers (Umutlu, 2022). Through these studies, we gain a better understanding of the effects of STEM activities on preservice teachers' knowledge, skills, attitudes, and behavior towards STEM education. This knowledge can help in the development of effective STEM teacher training programs and ultimately, enhance the quality of STEM education for future generations.

Research Trends and Patterns Involving Inservice Teacher Participation: Sampling from Teachers Working in the School Districts



There is a limited number of studies on STEM education carried out with in-service teachers compared to teacher candidates. However, some studies have been conducted to **understand the perceptions, views, and awareness of in-service teachers** regarding STEM education (Acıksoz et al., 2020; Çınar& Terzi, 2021;Çolak& Buldur,2022; Karademir Coşkun et al., 2020; Özcan& Koştur, 2018). Workshops are commonly used as a professional development approach for in-service teachers in STEM education. Several studies have examined teachers' perceptions of STEM applications, including Altun and Apaydın(2022), Yucelyigit, (2021)andYildirim et al., (2022).

In addition, **specific training programs** have been developed for STEM education, such as STEM focused professional development (Bozan, & Anagün,2019), the mentorship model (Yabaş & Boyacı, 2022; Yabas & Bozoglu, 2022)and the STEM teacherinstitute trainingmodel(Yildirim, 2020). Interdisciplinary activities are also used to integrate computational thinking into STEM activities. Ozdinc et al., (2022) presented an unplugged programming activity for this purpose. Moreover, Aykan and Yildirim (2022) introduced the Lesson Study Model into Distance STEM Education. Furthermore, parent involvement in early engineering education was investigated by Ata-Akturk & Demircan (2021), while MOOCs in STEM education were studied by Yildirim (2022).

Another group of studies focused on **understanding in-service teachers' STEM classroom practices**. Aydin (2020) examined prerequisites for elementary school teachers before practicing STEM education, Demircan, (2022)determined preschool teachers' perspectives regarding integrative STEM practices, and Tezcan Şirin et al (2022) examined STEM activities in school science textbooks. Similarly, Preschool teachers' and middle school science teachers preparation and views were investigated by Ata and Arslan(2021) and Yildirim (2021), while Aydogdu et al., (2020) examined the change in perceptions of science teachers about E-STEM. Mumcu et al. (2023)and Durak et al. (2022) investigated teachers' views on computational thinking through design-based or art-integrated practices.



State-of-the Art Research Initiatives in Master Thesis & Doctoral Dissertations

Initially, our team's focus was to examine the prevailing trends, challenges, and best practices in STEM education. To achieve this, we analyzed 230 Master's and PhD theses published within the last 5 years. Subsequently, we set the scope of our analysis to cover the last 5 years (2018-2023) and specifically targeted the theses published in Turkish Thesis Center (YÖK Tez) and carried out in Türkiye Universities. All of the selected theses had STEM education as their main topic.

We developed a search strategy that involved identifying relevant keywords and their synonyms for STEM education, such as Science, Technology, Engineering, Mathematics, STEM education, STEM teaching, STEM learning, STEM curriculum, STEM pedagogy, and STEM assessment. We only used official thesis databases (YÖK Thesis) to conduct the search and extracted pertinent information from the selected theses, such as research objectives, methods, findings, and participants. We then organized the collected data in a spreadsheet or database for convenient analysis. Our team performed a descriptive analysis of the collected data, including the frequency of STEM education topics, research methods used, and participants involved. Additionally, we conducted an analysis of the various topics addressed in the studies. The main findings of our analysis are presented in Figure 3.

The evaluation of STEM Education Master's and PhD Theses has concluded, comprising a total of 230 theses. These theses encompassed 10 preschool students, 25 elementary school students, 78 middle school students, 7 gifted/talented students, and 10 high school students. In addition, 39 prospective/preservice teachers and 35 active teachers took part in the study. Moreover, 13 published articles, 3 books, and curriculums were scrutinized for qualitative analysis. The analysis also involved 10 stakeholders, such as families and researchers. Individuals can access data files, and analysed theses through the Open Science Framework website (https://osf.io/mcyv7/?view_only=2d17fc24b6974a20a945a49c6a21bf71).



Sources of Data & Participants of Thesis Analyzed in Country Report

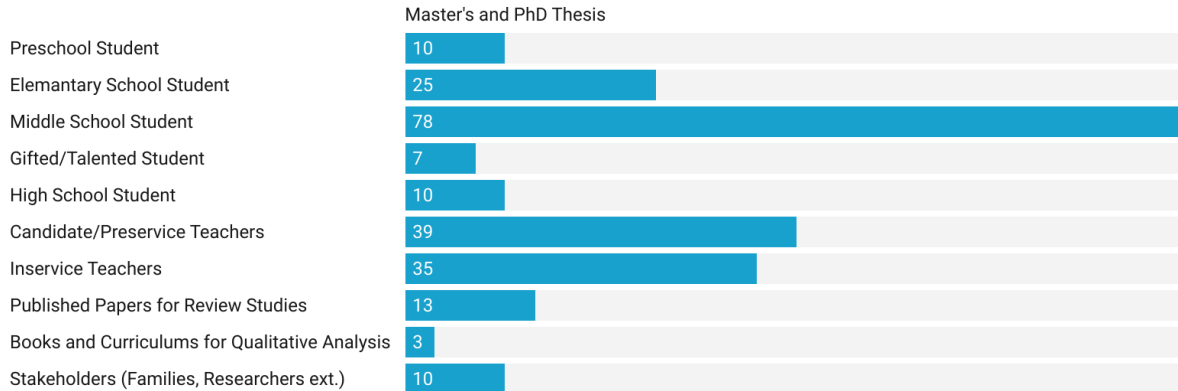


Figure 3.

Sources of Data & Participants of Thesis Analyzed in Country Report

The analyzed thesis emphasizes various developmental aspects in preschool children, as revealed by the frequency data presented in Figure 4. The table comprises eight distinct topics, each assigned a frequency score of either 1 or 5. The first topic, science process skills, refers to the capacity of preschool children to comprehend and apply scientific principles and methodologies. The second topic, age-appropriate developmental skills, pertains to the acquisition of skills typically observed in preschoolers, such as social skills, language development, and gross and fine motor skills. Creativity is the third topic, indicating the ability of preschoolers to express themselves through art and imaginative play. The remaining topics relate to different areas of academic development, such as academic self-esteem, critical thinking, problem-solving skills, and academic progress. These topics are critical for preschool children as they lay the groundwork for their future academic success and lifelong learning. Taken together, the frequency table suggests that the analyzed thesis focuses on a wide range of developmental domains in preschool children, including science, creativity, and academic skills.

Moreover, based on the frequency table provided, it appears that the analyzed thesis focuses on a range of topics related to the development and education of elementary school students. The table includes 12 different topics, each of which has a frequency ranging from 1 to 11, suggesting that the thesis covers a variety of themes with varying levels of importance. The most frequently occurring topic in the table is attitude towards STEM, with a frequency of 11.



Topics for STEM Education Examined in Master's and PhD Theses

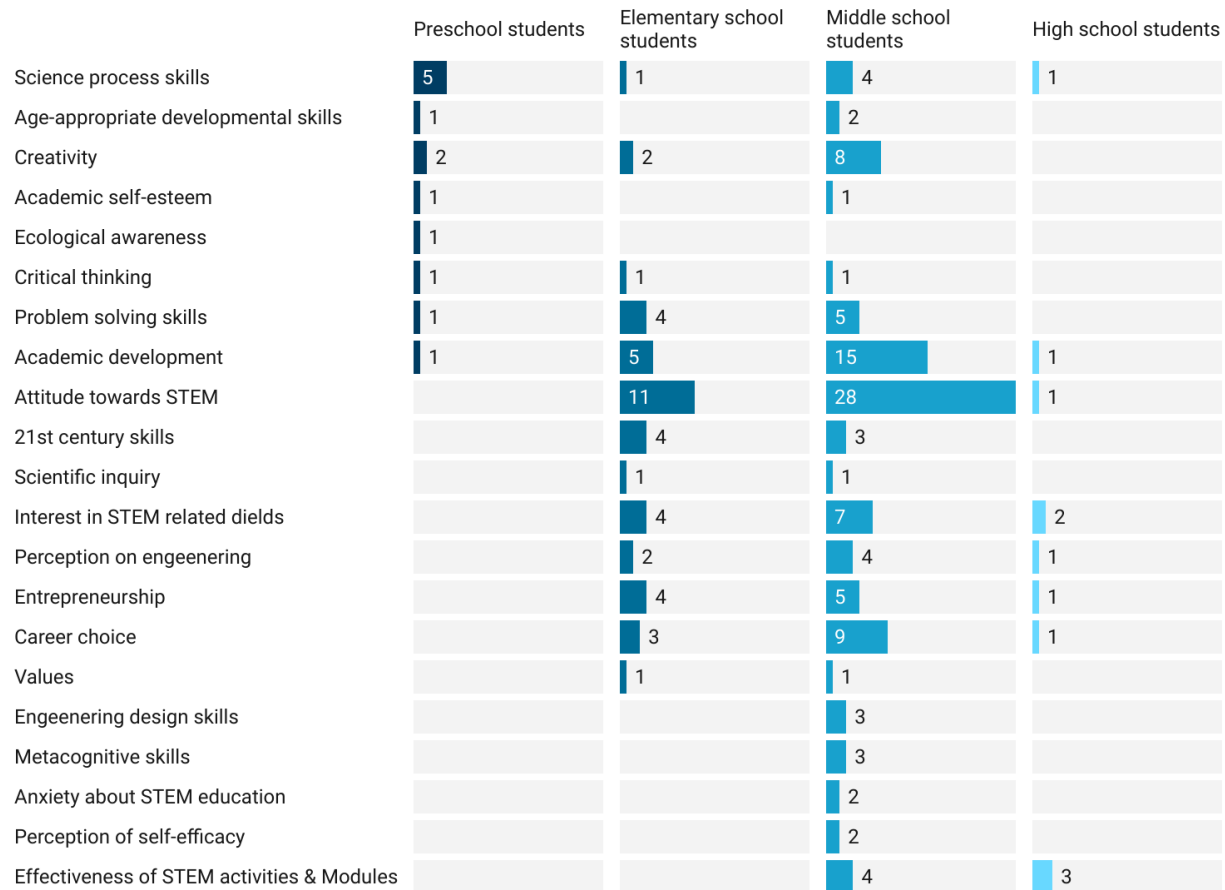


Figure 4.

Topics of Thesis Analyzed in Country Report

This suggests that the theses are primarily focused on exploring how students' attitudes towards science, technology, engineering, and math impact their academic and career aspirations. Understanding students' perceptions of STEM fields is crucial for educators, as it can inform curriculum development and teaching strategies. In addition to attitude towards STEM, the frequency table reveals several other important topics related to academic and personal development. Academic development has a frequency of 5, indicating that the thesis likely explores the academic skills and abilities of elementary school students. Problem solving skills, 21st century skills, interest in STEM related fields, and entrepreneurship all have frequencies of 4, suggesting that the thesis may delve into the ways in which these skills and interests can be fostered in elementary school students. Creativity and critical thinking, both with a frequency of 2, may be areas of focus for the thesis in terms of developing students' ability to approach problems in new and innovative ways. Perception on engineering, career choice, and values, all with frequencies of 1, suggest that the theses are exploring these topics in less depth but still touch



on their importance for elementary school students. Overall, the frequency table indicates that the analyzed thesis explores a wide range of topics related to the development and education of elementary school students, with a particular emphasis on STEM-related fields and skills. By examining these topics, the thesis provides insights into effective strategies for cultivating students' academic and personal growth, as well as their interest and engagement in STEM fields.

Furthermore, Figure 4 provided covers a range of topics related to middle school students and their attitudes, skills, and perceptions towards STEM education. The table shows that the most frequently mentioned topic is "attitude towards STEM," which was mentioned 28 times. This suggests that researchers and educators are interested in understanding how middle school students perceive STEM subjects and how they feel about them. Other notable topics that were mentioned multiple times include "academic development" (15), "career choice" (9), "creativity" (8), and "interest in STEM-related fields" (7). These topics suggest that there is a focus on understanding how to engage middle school students in STEM subjects and how to encourage them to pursue careers in STEM-related fields. In addition, there are several topics that were only mentioned once or a few times, such as "academic self-esteem," "critical thinking," and "scientific inquiry." These topics highlight the importance of developing specific skills and attitudes that are necessary for success in STEM subjects. Overall, the frequency table provides a broad overview of the different topics that researchers and educators are interested in exploring related to middle school students and STEM education. These topics can help guide future research and program development aimed at improving STEM education and increasing student engagement and success in STEM subjects.

In addition, the Figure 4 presented includes several topics related to STEM education among high school students. One of the most prominent themes is the interest in STEM-related fields, which was ranked with a frequency of 2. This suggests that students in high school have a significant interest in pursuing careers or fields of study related to science, technology, engineering, and mathematics. Another topic that is relevant to STEM education is the effectiveness of STEM activities and modules, which was rated with a frequency of 3. Attitude towards STEM and perception of engineering were rated with a frequency of 1 each, suggesting that there is room for improvement in these areas. It is important to explore the reasons why students could have negative attitudes towards STEM or engineering and develop strategies to address these issues. Academic development, entrepreneurship, and career choice were also rated with a frequency of 1 each. These topics are all important for students' success in the STEM fields, as they relate to developing the skills and knowledge needed to succeed in these areas. Overall, this frequency table provides valuable insights into the current state of STEM education among high school students.



Topics for STEM Education Examined in Master's and PhD theses

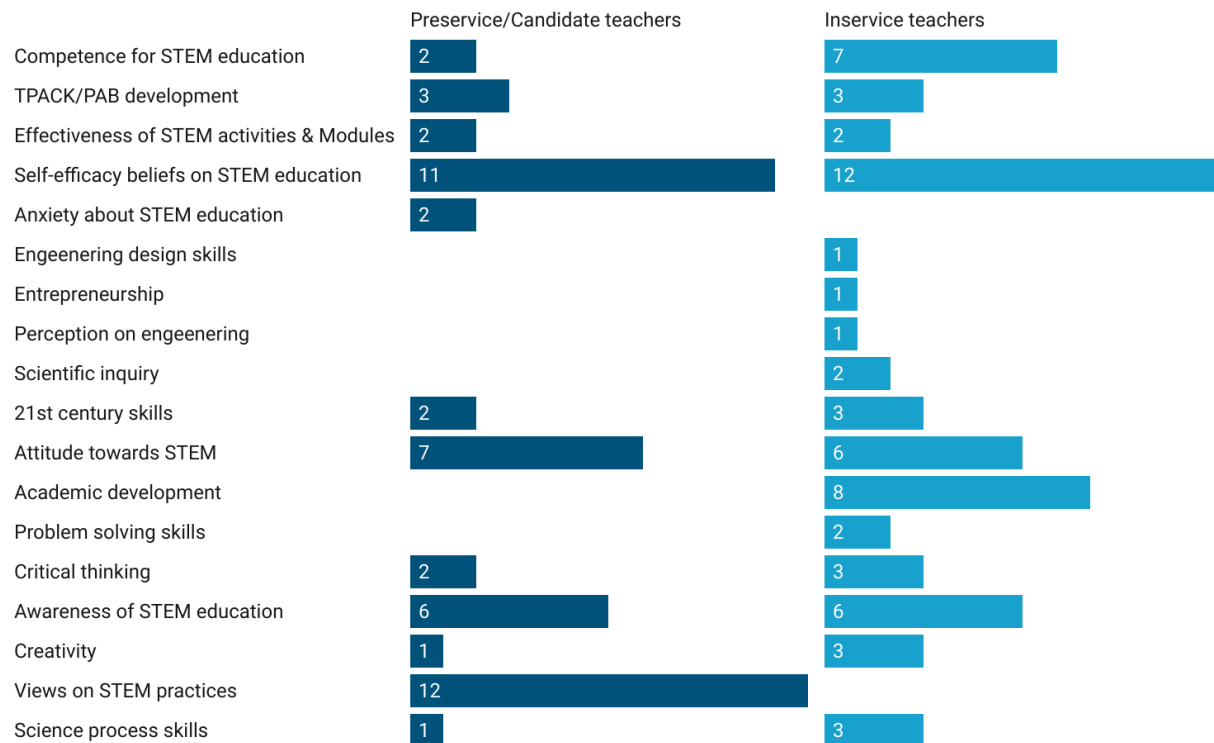


Figure 5

Topics of Thesis Analyzed in Country Report (Sampled from Preservice & Inservice Teachers)

Figure 5 presents the topics analyzed in a thesis on Preservice/Candidate teachers. The table indicates the number of times each topic was mentioned in the thesis. Based on the table, it appears that the thesis focused more on the candidates' views and awareness of STEM practices, as well as their self-efficacy beliefs on STEM education. These topics were mentioned 12 and 11 times, respectively. The candidates' attitudes towards STEM education and their competence for STEM education were also discussed in the thesis, with 7 and 2 mentions, respectively. The low frequency of mentions for creativity, critical thinking, 21st-century skills, anxiety about STEM education, and effectiveness of STEM activities & modules indicate that these topics were not the primary focus of the thesis. The findings suggest that the thesis primarily focused on exploring the candidates' views, awareness, and self-efficacy beliefs on STEM education. The thesis likely aimed to understand the candidates' perceptions of STEM education and identify ways to improve their preparation for teaching STEM subjects. Overall, the topics analyzed in the thesis reflect the importance of STEM education and the need to equip teachers with the necessary knowledge, skills, and attitudes to effectively teach STEM subjects. The results of the thesis could be used to inform teacher training programs and curriculum development to better prepare candidates for teaching STEM subjects.

In addition, Figure 5 provides a quick overview of the various topics analysed in the thesis related to inservice teachers. From the table, it is evident that self-efficacy beliefs on



STEM education and academic development are the most frequently analysed topics, with 12 and 8 occurrences respectively. STEM education is a rapidly evolving field, and the topics covered in this thesis highlight the skills, competencies, and attitudes that are essential for inservice teachers to effectively teach STEM subjects to their students. The high frequency of topics related to STEM education, such as awareness of STEM education, attitude towards STEM, competence for STEM education, and TPACK/PAB development, highlights the importance of addressing these areas in inservice teacher training programs. The topics of creativity, critical thinking, 21st century skills, science process skills, and problem-solving skills are also frequently analysed in the thesis. These skills are essential for students to develop in order to succeed in STEM fields, and it is important for inservice teachers to possess these skills themselves to effectively teach them to their students. The low frequency of certain topics, such as perception on engineering, entrepreneurship, and engineering design skills, could indicate that further research is needed in these areas to fully understand their relevance to inservice teacher training programs. Overall, the topics analysed in this thesis highlight the importance of developing the skills, attitudes, and competencies necessary for inservice teachers to effectively teach STEM subjects to their students.



State-of-the-art STEM centers& STEM-related interactiveexhibitsandworkshops in ScienceCentersandMuseums

STEM centers play a crucial role in Türkiye STEM education initiatives by promoting, supporting, and providing resources for STEM education. STEM centers are typically established within universities, research institutions, or other organizations and work to enhance the quality of STEM education (Table 3).Some of the roles of STEM centers in Türkiye STEM education initiatives include:

1. Developingandimplementing STEM education: STEM centersdevelopandimplement STEM activitiesthatarealigned with national standards and provide opportunities for hands-on learning.
2. Training and professional development for teachers: STEM centers provide training and PD for teachers to improve their knowledge and skills in teaching STEM subjects.
3. Providing STEM resources: STEM centers provide a range of resources such as books, journals, software, and hardware for use by students and teachers.
4. Supporting research: STEM centers support research in STEM education to develop evidence-based approaches to teaching and learning.
5. Collaborating with industry: STEM centers collaborate with industry partners to provide opportunities for students to engage in real-world STEM experiences and learn about STEM careers.

Many critical and pioneering steps have been taken towards the establishment of STEM centers in Türkiye. For example, In June 2016, MEB emphasized the significance of establishing STEM centers in its report on STEM education. The report included a framework for the STEM education action plan, which highlighted the following objectives: setting up STEM education centers, conducting STEM research in collaboration withuniversities, training teachers in STEM education approaches, updating curricula to integrate STEM education, and creating teaching environments and materials for STEM education in schools.



Table 3

STEM centers established within universities, research institutions, or other organizations

Center	Funded by	Link
STEM Education and Coordination Center	Co-funded by EU and Türkiye	https://stemegitimmerkezi.com/
STEM School - Istanbul Aydın University	University funded	http://stemokulu.com/stem-okulu-hakkinda/
STEM and Science Center	Funded by Erasmus+ Ka2 Project	https://www.urfastem.gov.tr/
Diyarbakır STEM Center	Co-funded by Development agency and Ministry of Education	https://www.diyarbakirstemmerkezi.com/hakkimizda
Kahramanmaraş Stem Center	Funded by Provincial Municipality	https://kahramanmaraş.bel.tr/stem-merkezi
Bursa Innovation Center	Co-funded by Provincial Directorate of National Education and Development Agency	https://www.bursainovasyonmerkezi.com/ortaokul-ogrencileri-icin-stem-atolyesi/
Ülker AYDIN STEM Center	Funded by Provincial Municipality	https://tarsus.bel.tr/tr/stem-merkezi/
Turkish Stem Education Association	A researcher initiative	http://stemtr.org/
Istanbul STEM Learning Center Project	Funded by Development Agency	https://i-stemmerkezi.com/?fbclid=PAAaZy4dRuRAi2cgxELKzfWELvg-Um8UMqL_PMOi3zJOPPBVvNTASpa9g3tz0
STEM Lab	University funded	https://www.izu.edu.tr/akademik/fakulteler/egitim-fakultesi/laboratuvarlar/stem-laboratuvari
Hacettepe STEM & Maker Lab	University funded	https://hstem.hacettepe.edu.tr/
Muğla Sıtkı Koçman University Science Education Research & Application Center	University funded	https://mubem.mu.edu.tr/tr/mubem-projeler-1739
BİLTEM Center for Science Technology Engineering and Mathematics Education	University funded	https://biltemm.metu.edu.tr/tr



Moreover, Istanbul Aydın University, a leading institution in the field of STEM education, has established a STEM center to provide top-notch laboratory facilities and exemplary education in STEM for teachers and students. The center aims to bring together individuals and organizations involved in STEM activities in Türkiye and provide support for all STEM initiatives in the country (Akgündüz et al., 2015). According to a report, universities are the ideal institutions to establish STEM centers, with Hacettepe University and Istanbul Aydın University already having done so. However, these efforts are not enough to fully integrate STEM education into formal education. To achieve this, education and engineering faculties should form STEM centers and collaborate with MEB's STEM center. These centers can offer research opportunities to integrate STEM education into the education system, provide up-to-date training, update the curriculum, offer professional development opportunities for teachers, facilitate project partnerships, and organize competitions for teachers and students. A coordinated structure is proposed in the diagram below.

STEM centers have been emphasized as necessary in academic studies and reports (Akgündüz et al., 2015; Uğraş, 2017; Türk, 2019; Uyar, Canpolat, Şan, 2021). Bahçeşehir University established the BAUSTEM STEM Center within their Teacher Professional Development Application and Research Center in 2016 to provide training to increase teachers' STEM application skills. The STEM: Leader Teacher Professional Development Program aims to maintain effective communication and interaction between teachers and academics (see <https://inteach.org/hakkimizda/>). The Middle East Technical University (METU) BİLTEM Education Application and Research Center aims to advance education in science, technology, engineering, and mathematics through studies conducted by a group of researchers consisting of faculty members from different disciplines. Their objectives include providing educational opportunities to schools, teachers, and students in the relevant fields and training teacher candidates at the undergraduate level (see <https://inteach.org/hakkimizda/>). Hacettepe STEM & Maker Lab, established within the body of Hacettepe University in 2009, participates in projects within the scope of European Union Framework Programs to raise individuals not only at the national but also at the international level (see <https://hstem.hacettepe.edu.tr/>). Below is a table displaying the STEM centers and laboratories that universities have established collectively (Table 4).



Table 4
STEM Centers within universities in Turkey

University	Name of the Center	Year of Foundation
Hacettepe University	Hacettepe Science, Technology, Engineering and Mathematics Education and Applications Laboratory	2009
Yalova University	Science and Technology Application and Research Center	2011
Muğla Sıtkı Koçman University	Science Education Application and Research Center	2013
İstanbul Aydın University	Istanbul Aydın University STEM Laboratory	2015
Bahçeşehir University	Teacher Professional Development Application and Research Center – (BAUSTEM)	2016
Van Yüzüncü Yıl University	Science Technology Engineering and Mathematics Education Application and Research Center	2017
Yıldız Technical University	STEM Labrotary	2017
Aydın Adnan Menderes University	Science, Technology, Engineering and Mathematics Education Application and Research Center	2018
İstanbul Gedik University	Science, Technology, Engineering, Mathematics Application and Research Center	2018
Muş Alparslan University	STEM Education Application and Research Center	2019
İstanbul Zaim University	Faculty of Education STEM laboratory	2018
ODTU (Ortadoğu Technical University)	BİLTEM Science, Technology, Engineering and Mathematics Education Application and Research Center	2017

Note. Source: Polat, Ö. & Bardak, M. (2019). STEM Approach in Early Childhood in Türkiye. International Journal of Social Science Research, 8(2), 18-41.

Integrating STEM (science, technology, engineering, and mathematics) practices into science centers and museums can be an effective way to engage visitors with hands-on, interactive exhibits that promote inquiry-based learning. Here are some ways to integrate STEM practices into science centers:

1. Offer interactive exhibits that promote inquiry-based learning: Science museums can create exhibits that encourage visitors to ask questions, make observations, and test hypotheses.



For example, a physics exhibit might feature hands-on experiments with pendulums or demonstrate the properties of sound waves using interactive displays.

2. Use technology to enhance exhibits: Science museums can use technology to enhance exhibits and provide visitors with new ways to interact with scientific concepts. Virtual reality, augmented reality, and interactive displays can help visitors visualize complex scientific concepts in new and exciting ways.
3. Offer STEM-related programs and workshops: Science museums can offer programs and workshops that provide visitors with opportunities to learn about STEM concepts through hands-on activities. For example, a robotics workshop might teach visitors how to build and program a robot.
4. Partner with local schools and universities: Science museums can partner with local schools and universities to provide educational programs that complement classroom learning. This can include field trips, science fairs, and science camps.
5. Encourage visitors to participate in citizen science projects: Science museums can encourage visitors to participate in citizen science projects, which allow them to contribute to real scientific research. For example, a museum might host a bird-watching event and ask visitors to record their observations for a research project. Table 5 showcases noteworthy science centers and museums that receive high visitation.

STEM Centers in Türkiye offer both STEM Basic Level and STEM Advanced Level Trainings, and they provide ongoing training for teachers. The activities at the center are coordinated with the STEM activities planned by teachers in schools, and the center monitors students' interest and attitude scales, as well as their academic achievements. Trained teachers are visited periodically, and a science festival is held annually to exhibit student and teacher products. Some STEM centers also provide guidance activities for teachers on integrating STEM into their curriculum, as well as repairing and supporting materials used in STEM education.

STEM education is available at all levels, from kindergarten to university students, and the centers are generally located in city centers with easy transportation access. Free education is provided to students, but due to high demand, some centers can only offer STEM education one day a week per student. STEM Centers offer a variety of services and resources to their visitors. The event implementation times are flexible and are determined by an appointment system in some centers, while others provide training between 16:00 and 22:00. The physical conditions of some centers are considered sufficient to meet the needs of their visitors. The STEM classes available in these centers cater to a wide range of ages and educational levels, from kindergarten to vocational high school. The classes cover various concepts such as industrial robotics, coding, and scientific inquiry. The centers also provide individual workshops and intelligence games workshops. In addition, the centers offer several STEM workshops for kindergarten, primary, secondary, and high schools. Some centers are equipped with fischer technical building sets, Lego and Arduino robot sets, science laboratory materials, three-dimensional printers, and computers (Bircan, Köksal & Cımbız, 2019; Uyar, Canpolat & Şan, 2021; Karaduman & İnanç, 2023). Public and Private Universities provide various resources and training programs for teachers, undergraduate students, primary and secondary school



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students. Istanbul Aydın University is one of the institutions that has established STEM centers and laboratories to contribute to STEM education. The STEM Laboratory at Istanbul Aydın University offers a STEM teacher training program, both face-to-face and online education programs, as well as integrated STEM education for students. Additionally, the university also provides support to institutions that are interested in establishing their own STEM labs. Additionally, Istanbul Aydın University's STEM center also focuses on environmental STEM education and provides STEM education to vocational and technical high schools.



Table 5.

Noteworthy Science Centers and Museums That Receive High Visitation

Center	Funded by	Info	Link
Bursa Science and Technology Center: BTM	Bursa Metropolitan Municipality's vision project	The goal of the Bursa Science and Technology Center is to promote sustainable development, foster a society based on science, and train future scientists, with the aim of accelerating Turkey's progress in the field of science and technology and serving as a model for the entire country.	http://www.bursabilimmerkezi.org/
Konya Science Center	Konya Metropolitan Municipality	The Konya Science Center, established by the Konya Metropolitan Municipality and supported by TÜBİTAK, is Turkey's first science center. Its goal is to cultivate a passion for science in people aged 7 to 70 and encourage interest in science throughout all levels of society.	https://www.konyabilimmerkezi.com/
Kayseri Science Center	Kayseri Metropolitan Municipality and TUBİTAK	The goal is to merge theory and practice for young individuals to work, create, succeed, and adapt to current demands.	https://www.kayseribilimmerkezi.com/
Space Camp Turkey	Private funded Science Museum	Space Camp Turkey, a space and center, is focused on motivating young people to pursue careers in science, mathematics and technology. In programs related to STEAM (Science-Technology-Engineering-Art-Mathematics) learning approaches; increasing their interest in creative sciences through applied training; Suggestions for establishing dialogue, questioning and critical thinking are aimed to be guiding. A dynamic and fun journey used by space-related operations, both for children and adults; training in communication, teamwork and management. Providing scientific education, Space Camp Turkey, headquartered in Huntsville Alabama, has the American Space Sciences Exhibition Commission License and is a member of the Turkish Camps Association.	https://www.spacecampsturkey.com
Eskişehir Science and Experiment Center	Eskişehir Metropolitan Municipality	The Eskişehir Science Experiment Center is created with the aim of educating our upcoming generation. It provides an opportunity for children who are interested in science, eager to learn by experimenting and observing, to utilize various experimental tools and gain new knowledge. Both young and old who share a common curiosity are welcome to visit the center.	http://www.eskisehirbilimdeneymerkezi.com/default.aspx
Istanbul Technical University (ITU) Science Center	Istanbul Technical University	The ITU Science Center aims to provide students of all ages with hands-on experiences in science, technology, and nature's fundamental laws. Its goal is to promote scientific culture in society, making science and technology accessible and popular, and inspiring people of all ages to engage in these fields.	https://www.bilimmerkezi.itu.edu.tr/hakkinda/itu-bilim-merkezi/
Kocaeli Science Center	Kocaeli Metropolitan Municipality-TUBİTAK	The Kocaeli Science Center, a collaboration between Kocaeli Metropolitan Municipality and TUBİTAK, intends to unite science and technology with people of various ages and levels of understanding, while promoting the significance of these fields in society.	http://www.kocaelibilimmerkezi.com/



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Moreover, BİLTEM: The Science, Technology, Engineering and Mathematics Education Application and Research Center, as located in Middle East Technical University, offers various programs and projects to support STEM education. These initiatives include teacher training workshops, STEM days, as well as national and international projects and studies. The center also conducts interdisciplinary practices and innovation development workshops, such as the Edusteam Project, to promote STEAM studies. Bahçeşehir University's BAUSTEM center offers a range of programs and resources to support STEM education. These include a Young STEM researcher and practitioner program, designed to provide support to STEM centers, as well as several STEM education programs. The center has also published educational books on STEM Theory and Practices, which provide a basic guide for teachers, as well as guides specifically tailored for primary schools (See Figure 6).



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Note. Images are taken from BAUSTEM official website

Figure 6. STEM Initiatives and Books Published by BAUSTEM

The Payas Stem Center is a remarkable educational facility located in the Payas district of Hatay province in Türkiye. This center is housed in a two-story building spanning an area of 700 m2 and is notable for being established outside of metropolitan cities. Among its offerings are classes in Robotic Coding, Mathematical Modeling, Scientific Inquiry, World of Words, and Mind Games sections. Students who attend classes at the Payas Stem Education Center benefit from engaging workshops that utilize a variety of educational tools, including Sensors, Electronic Circuits, 3D Printers, Lego Minstorms EV3s, and Mind Games.



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In conclusion, the evaluation of academic research, reports, and studies conducted in STEM centers reveals a diverse range of applications, projects, and workshops aimed at promoting STEM education in Türkiye, alongside supportive initiatives for newly established centers. Moreover, valuable educational resources, including books and brochures, are being developed to aid teachers and students in the pursuit of academic excellence. These efforts serve as a testament to the importance of STEM education and the commitment of Turkish institutions to nurturing a thriving culture of scientific inquiry and technological innovation.



REFERENCES

*Articles with TR Index Analyzed in This Paper.

4th International STEM Education Conference. STEMpd. Retrieved April 17, 2023, from <https://www.stempd.net/>

Abanoz, T., & Yabas, D. (2022). My world of machines: an integrated STEM education curriculum for early childhood teachers. *European Early Childhood Education Research Journal*. <https://doi.org/10.1080/1350293X.2022.2127822>

Acar, D., Ecevit, T. & Büyükşahin, Y. (2020). Fen bilimleri öğretmen adaylarının STEM eğitime yönelik metaforik algıları. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, 21(3), 1839-1873. *TR Indexed

Acıksoz, A. , Ozkan, Y. Ö. & Dokme, I. (2020). Adaptation of the STEM Value-Expectancy Assessment Scale to Turkish Culture. *International Journal of Assessment Tools in Education*, 7 (2) , 177-190. <https://doi.org/10.21449/ijate.723408> *TR Indexed

Adsay, C. , Korkmaz, Ö. , Çakır, R. & Uğur Erdoğan, F. (2020). Ortaokul öğrencilerinin blok temelli kodlama eğitimine dönük öz-yeterlik algı düzeyleri, STEM ve bilgisayarca düşünme beceri düzeyleri. *Eğitim Teknolojisi Kuram ve Uygulama*, 10(2), 469-489. <https://doi.org/10.17943/etku.696224> *TR Indexed

Akar, H. & Yadigaroglu, M. (2021). Fen, teknoloji, mühendislik ve matematik (FETEMM) temelli etkinliklerin 5. sınıf öğrencilerinin madde ve değişim ünitesindeki kavramları günlük yaşamla ilişkilendirmelerine etkisi. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 23(1), 57-81 . <https://doi.org/10.17556/erziefd.656886> *TR Indexed

Akçapınar, G. & Coşgun, E. (2019). Öğrencilerin STEM eğitimi tercihlerinin veri madenciliği yaklaşımı ile tahmin edilmesi. *Eğitim Teknolojisi Kuram ve Uygulama*, 9(1) , 73-88. <https://doi.org/10.17943/etku.429785> *TR Indexed

Akgün, K. & Türel, Y. K. (2021). Bilgisayar ve öğretim teknolojileri eğitimi bölümü öğrencilerinin stem yaklaşımına yönelik farkındalıklarının belirlenmesi. *Eğitim Teknolojisi Kuram ve Uygulama*, 11(1), 116-128. <https://dergipark.org.tr/tr/pub/etku/issue/60079/771011> *TR Indexed

Akgündüz, D., Aydeniz, M., Çakmakçı, G., Çavaş, B., Corlu, M. S., Öner, T., & Özdemir, S. (2015). A report on STEM Education in Türkiye: A provisional agenda or a necessity? [Technical Report]. İstanbul, Türkiye: Aydın Üniversitesi. Retrieved from <http://www.aydin.edu.tr/belgeler/IAU-STEM-Egitimi-Turkiye-Raporu-2015.pdf>

Akkaş Baysal, E. , Ocak, G. & Ocak, İ. (2020). Kodlama ve arduino eğitimleri ile ilgili lise öğrencilerinin görüşleri. *Elektronik Sosyal Bilimler Dergisi*, 19(74), 777-796. <https://doi.org/10.17755/esosder.625496> *TR Indexed



- Akpınar, B. C., & Akgunduz, D. (2022). The Effect of STEM Applications in Preschool on Students' Carrier Goals and Perceptions of Engineering. *INTERNATIONAL JOURNAL OF EARLY CHILDHOOD*, 54(3), 361–381. <https://doi.org/10.1007/s13158-022-00330-1>
- Alan, B., Zengin, F. K., & Kececi, G. (2019). Using STEM applications for supporting integrated teaching knowledge of pre-service science teachers. *Journal Of Baltic Science Education*, 18(2), 158–170. <https://doi.org/10.33225/jbse/19.18.158>
- Alan, B., Zengin, F. K., & Kececi, G. (2021). Effects of Science, Technology, Engineering, and Mathematics Education Using Algodo to Prospective Science Teachers' Scientific Process and Education Orientation Skills. *Journal of Education*, 0(0). <https://doi.org/10.1177/00220574211044542>
- Altan, E. B., & Ucuncuoglu, I. (2019). Examining the Development of Pre-Service Science Teachers' STEM-Focused Lesson Planning Skills. *Eurasian Journal Of Educational Research*, 83, 103–124. <https://doi.org/10.14689/ejer.2019.83.5>
- Altun, E. & Apaydın, Z. (2022). Sınıf öğretmenlerinin STEM yaklaşımına yönelik farkındalık düzeyleri ve tutumları. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 19(2), 527-545. <https://doi.org/10.33711/yyuefd.1108245> *TR Indexed
- Arslanhan, H. & İnaltekin, T. (2020). Tasarım Temelli Öğrenme Uygulamalarının Fen Bilimleri Öğretmen Adaylarının STEM Anlayışlarını Geliştirmeye Etkisi . *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi* , 17 (1) , 231-265 . <https://doi.org/10.33711/yyuefd.691585> *TR Indexed
- Ata Aktürk A., Demircan, H.Ö.; Şenyurt, E. & Çetin, M. (2017). Turkish early childhood education curriculum from the perspective of STEM education: A document analysis. *Journal of Turkish Science Education*, 14(4), 16–34.
- Ata-Akturk, A. (2023). ``Teacher, I know how to do it{'}``: An engineering design-based STEM activity on the concepts of forces and floating/sinking for young problem solvers. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 60(1), 12–24. <https://doi.org/10.1080/00368121.2022.2128709>
- Ata-Akturk, A., & Demircan, H. O. (2021). Supporting Preschool Children's STEM Learning with Parent-Involved Early Engineering Education. *Early Childhood Education Journal*, 49(4), 607–621. <https://doi.org/10.1007/s10643-020-01100-1>
- Ata-Akturk, A., & Demircan, H. O. (2022). Engineers and engineering through the eyes of preschoolers: a phenomenographic study of children's drawings. *European Early Childhood Education Research Journal*, 30(4), 495–514. <https://doi.org/10.1080/1350293X.2021.1974067>
- Ata, A. O. & Arslan, H. Ö. (2021). Fen bilimleri öğretmenlerinin STEM eğitimi yaklaşımına yönelik hazırbulunuşluk durumlarının incelenmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 18(2), 405-436. <https://doi.org/10.33711/yyuefd.1029055> *TR Indexed



- Ata, R., & Cevik, M. (2020). Understanding predictor effects of computational thinking skills and media and technology use and attitudes of pre-service teachers for STEM awareness. *Kedi Journal Of Educational Policy*, 17(1), 99–121.
- Ayaz, M., Gülen, S. & Gök, B. (2020). STEM etkinliklerinin uygulanması sürecinde elektronik portfolyo kullanımının sekizinci sınıf öğrencilerinin fen bilimleri dersi akademik başarısına ve STEM Tutumuna etkisinin incelenmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 17 (1), 1153-1179. <https://doi.org/10.33711/yyuefd.801394> *TR Indexed
- Aydeniz, M. (2017). Eğitim sistemimiz ve 21. yüzyıl hayalimiz: 2045 hedeflerine ilerlerken, Türkiye için STEM odaklı ekonomik bir yol haritası. University of Tennessee, Knoxville.
- Aydın, E. & Karslı, F. (2019). Yedinci sınıf öğrencilerinin STEM etkinlikleri hakkındaki görüşleri: karışımların ayrıştırılması örneği. *Ondokuz Mayıs University Journal of Education Faculty*, 38(1), 35-52. <https://dergipark.org.tr/tr/pub/omuefd/issue/46119/439843> *TR Indexed
- Aydın, S. , Öztay, E. S. & Ekiz, B. (2021). Examination of pre-service chemistry teachers' STEM conception through an integrated STEM course. *Turkish Journal of Education*, 10(4), 251-273. <https://doi.org/10.19128/turje.894588> *TR Indexed
- Aydin-Gunbatar, S., Ekiz-Kiran, B., & Oztay, E. S. (2020). Pre-service chemistry teachers' pedagogical content knowledge for integrated STEM development with LESMeR model. *Chemistry Education Research And Practice*, 21(4), 1063–1082. <https://doi.org/10.1039/d0rp00074d>
- Aydin-Gunbatar, S., Oztay, E. S., & Ekiz-Kiran, B. (2021). Examination of pre-service chemistry teachers' STEM conceptions through an integrated STEM course. *Turkish Journal Of Education*, 10(4), 251–273. <https://doi.org/10.19128/turje.894588>
- Aydin-Gunbatar, S., Tarkin-Celikkiran, A., Kutucu, E. S., & Ekiz-Kiran, B. (2018). The influence of a design-based elective STEM course on pre-service chemistry teachers' content knowledge, STEM conceptions, and engineering views. *Chemistry Education Research And Practice*, 19(3), 954–972. <https://doi.org/10.1039/c8rp00128f>
- Aydin, G. (2020). Prerequisites for Elementary School Teachers before Practicing STEM Education with Students: A Case Study. *Eurasian Journal Of Educational Research*, 88, 1–39. <https://doi.org/10.14689/ejer.2020.88.1>
- Aydogan, B., & Cakiroglu, J. (2022). The Effects of Engineering Design-Based Instruction On 7th Grade Students' Nature of Engineering Views. *Journal Of Science Education And Technology*, 31(1), 68–80. <https://doi.org/10.1007/s10956-021-09931-2>
- Aydogdu, B., Kasapoglu, K., Duban, N., Ay, T. S., & Ozdinc, F. (2020). Examining change in perceptions of science teachers about e-stem. *Journal Of Baltic Science Education*, 19(5), 696–717. <https://doi.org/10.33225/jbse/20.19.696>



- Aykan, A., & Yildirim, B. (2022). The Integration of a Lesson Study Model into Distance STEM Education during the COVID-19 Pandemic: Teachers' Views and Practice. *Technology Knowledge And Learning*, 27(2), 609–637. <https://doi.org/10.1007/s10758-021-09564-9>
- Azgin, A. & Şenler, B. (2019). STEM in primary school: Students' career interest and attitudes. *Journal of Computer and Education Research*, 7(13), 2148-2896. *TR Indexed
- Bahşi, A. & Açıkgül Fırat, E. (2020). STEM etkinliklerinin 8. sınıf öğrencilerinin bilimsel süreç becerilerine, bilimsel epistemolojik inançlarına ve fen başarılarına etkisinin incelenmesi. *Ondokuz Mayıs University Journal of Education Faculty*, 39 (1), 1-22. Retrieved from <https://dergipark.org.tr/tr/pub/omuefd/issue/53755/616509>
- Balcin, M. D., & Ergun, A. (2019). Aeronautical and Space Engineers from the Eyes of Sixth Grade Students. *Pamukkale University Journal Of Education*, 45, 1–21. <https://doi.org/10.9779/PUJE.2018.219>
- BapoğluDümenci, S., Muş, E. & Demir, E. (2021). Analysis of Case Problems by STEM Activities in Children's Stories and Their Effect on Problem-Solving Skills. *Bartın University Journal of Faculty of Education*, 10(2), 378-389. *TR Indexed
- Baran, E., Bilici, S. C., Mesutoglu, C., & Ocak, C. (2019). The impact of an out-of-school STEM education program on students' attitudes toward STEM and STEM careers. *School Science And Mathematics*, 119(4), 223–235. <https://doi.org/10.1111/ssm.12330>
- Barron, B., & Darling-Hammond, L. (2008). Teaching for meaningful learning: A review of research on inquiry-based and cooperative learning. *Powerful Learning: What We Know About Teaching for Understanding*, 11-70.
- Basaran, M., & Erol, M. (2023). Recognizing aesthetics in nature with STEM and STEAM education. *Research In Science & Technological Education*, 41(1), 326–342. <https://doi.org/10.1080/02635143.2021.1908248>
- Bati, K., Yetisir, M. I., Caliskan, I., Gunes, G., & Sacan, E. G. (2018). Teaching the concept of time: A steam-based program on computational thinking in science education. *Cogent Education*, 5(1). <https://doi.org/10.1080/2331186X.2018.1507306>
- Beane, J. A. (1995). Curriculum integration and the disciplines of knowledge. *The Phi Delta Kappan*, 76(8), 616-622.
- BİLTEM Center for Science Technology Engineering and Mathematics Education. Retrieved April 17, 2023, from <https://biltemm.metu.edu.tr/tr>
- Bircan, M. A., & Calisici, H. (2022). The Effects of STEM Education Activities on Fourth Grade Students' Attitudes to Stem, 21st-Century Skills and Mathematics Success. *Eğitim Ve Bilim-Education And Science*, 47(211), 87–119. <https://doi.org/10.15390/EB.2022.10710>
- Bircan, M. A., Köksal, Ç., & Cımbız, A. T. (2019). Türkiye'deki STEM merkezlerinin incelenmesi ve STEM merkezi model önerisi. *Kastamonu Eğitim Dergisi*, 27(3), 1033-1045.



- Bolatlı, Z. & Korucu, A. T. (2018). Secondary school students' feedback on course processing and collaborative learning with web 2.0 tools-supported STEM activities. *Bartın University Journal of Faculty of Education*, 7(2), 456-478. *TR Indexed
- Bozan, M. A. & Anagün, S. Ş. (2019). STEM focused professional development process of elementary school teachers: An action research. *Anadolu Journal of Educational Sciences International*, 9(1), 279-313. *TR Indexed
- Bozan, S. & Kaya-capocci, S. (2022). Güçlü ve zayıf yönlerimi nasıl fark ederim öğretmen adaylarının yansıtıcı günlüklerden faydalanarak girişimci STEM ders planları geliştirmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 19 (3), 760-779. <https://doi.org/10.33711/yyuefd.1109425> *TR Indexed
- Buyukdede, M., & Tanel, R. (2019). Effect of the stem activities related to work-energy topics on academic achievement and prospective teachers' opinions on stem activities. *Journal Of Baltic Science Education*, 18(4), 507–518. <https://doi.org/10.33225/jbse/19.18.507>
- Cakir, N. A., Cakir, M. P., & Lee, F. J. (2021). We game on skyscrapers: the effects of an equity-informed game design workshop on students' computational thinking skills and perceptions of computer science. *ETR&D Educational Technology Research And Development*, 69(5), 2683–2703. <https://doi.org/10.1007/s11423-021-10031-6>
- Cakir, N. K., & Guven, G. (2019). Arduino-Assisted robotic and coding applications in science teaching: Pulsimeter activity in compliance with the 5E learning model. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 56(2), 42–51. <https://doi.org/10.1080/00368121.2019.1675574>
- Cakir, R., Korkmaz, O., Idil, O., & Erdogan, F. U. (2021). The effect of robotic coding education on preschoolers' problem solving and creative thinking skills. *Thinking Skills And Creativity*, 40. <https://doi.org/10.1016/j.tsc.2021.100812>
- Cakir, Z., & Yalcin, S. A. (2022). The Effect of the Montessori Approach-based STEM Activities on the Pre-school Pre-service Teachers' Lifelong Learning. *Pamukkale University Journal Of Education*, 56, 66+. <https://doi.org/10.9779/pauefd.1022966>
- Canbazoglu Bilici, S., Kupeli, M. A., & Guzey, S. S. (2021). Inspired by nature: an engineering design-based biomimicry activity. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 58(2), 77–88. <https://doi.org/10.1080/00368121.2021.1918049>
- Celik, S. A. (2022). An Investigation on the Effect of STEM Practices on Sixth-Grade Students' Problem-Solving Skills, Critical Thinking, and Attitudes Toward STEM. *Pamukkale University Journal of Education*, 56, 287+. <https://doi.org/10.9779/pauefd.1054678>
- Cetin, M., Demircan, H. O., Senyurt, E., & Akturk, A. A. (2020). An Analysis of Young Children's Preferences on STEM Activities in terms of Gender. *Journal of Education And Future-Egitim ve Gelecek Dergisi*, 18, 1–15. <https://doi.org/10.30786/jef.650246>



- Cevik, M. (2018). Impacts of the Project Based (PBL) Science, Technology, Engineering and Mathematics (STEM) Education on Academic Achievement and Career Interests of Vocational High School Students. *Pegem Egitim Ve Ogretim Dergisi*, 8(2), 281–305. <https://doi.org/10.14527/pegegog.2018.012>
- Ceylan, Ö. & Karahan, E. (2021). STEM odaklı matematik uygulamalarının 11. sınıf öğrencilerinin matematik tutum ve bilgileri üzerine etkisi. *Anadolu Journal of Educational Sciences International*, 11(2), 660-683. *TR Indexed
- Ciftci, A., & Topcu, M. S. (2022). Improving early childhood pre-service teachers' computational thinking teaching self-efficacy beliefs in a STEM course. *Research In Science & Technological Education*. <https://doi.org/10.1080/02635143.2022.2036117>
- Ciftci, A., Topcu, M. S., & Foulk, J. A. (2022). Pre-service early childhood teachers' views on STEM education and their STEM teaching practices. *Research In Science & Technological Education*, 40(2), 207–233. <https://doi.org/10.1080/02635143.2020.1784125>
- Coban, E., Korkmaz, O., Cakir, R., & Erdogmus, F. U. (2020). Attitudes of IT teacher candidates towards computer programming and their self-efficacy and opinions regarding to block-based programming. *Education And Information Technologies*, 25(5), 4097–4114. <https://doi.org/10.1007/s10639-020-10164-w>
- Crippen, K. J., & Archambault, L. (2012). Scaffolded Inquiry-Based Instruction with Technology: A Signature Pedagogy for STEM Education. *Computers in the Schools*, 29(1–2), 157–173. <https://doi.org/10.1080/07380569.2012.658733>
- Czerniak, C. M., Weber, W. B., Sandmann, A., ve Ahern, J. (1999). A literature review of science and mathematics integration. *School Science and Mathematics*, 99(8), 421-430.
- Çakır, Z. & Altun, S. (2021) Montessori yaklaşım temelli STEM etkinliklerinin okul öncesi öğretmen adaylarının problem çözme becerilerine etkisi. *Kuramsal Eğitim Bilim Dergisi*, 14(2), 93-119. *TR Indexed
- Çevik, M. & Abdioğlu, C. (2018) Bir bilim kampının 8. sınıf öğrencilerinin STEM başarılarına, fen motivasyonlarına ve üstbilişsel farkındalıklarına etkisinin incelenmesi. *İnsan ve Toplum Bilimleri Araştırma Dergisi*, 7(5), 304-327 *TR Indexed
- Çınar, S. & Terzi, S. Y. (2021). STEM eğitimi almış öğretmenlerin STEM öğretimi hakkındaki görüşleri. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 18(2), 213-245. <https://doi.org/10.33711/yyuefd.1028596> *TR Indexed
- Çil, E. & Özlen, S. (2019). Beşinci sınıf öğrencilerinin mühendis ve mühendislik algılarının incelenmesi. *Bolu Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 19(4), 1272-1287. *TR Indexed
- Çolak, E. & Buldur, A. (2022). Okul öncesi öğretmenlerinin STEM farkındalıklarının bazı demografik değişkenler açısından incelenmesi. *e-Kafkas Journal of Educational Research*, 9(2), 603-620. <https://doi.org/10.30900/kafkasegt.1016235> *TR Indexed



- Çolakoğlu, M. H., & Gökben, A. G. (2017). Türkiye’de eğitim fakültelerinde FeTeMM (STEM) çalışmaları. *İnformel Ortamlarda Araştırmalar Dergisi*, 2(2), 46-69.
- Dedetürk, A., Kirmuzigul, A. S., & Kaya, H. (2021). The effects of stem activities on 6th grade students’ conceptual development of sound. *Journal Of Baltic Science Education*, 20(1), 21–37. <https://doi.org/10.33225/jbse/21.20.21>
- Delen, I., & Sen, S. (2023). Effect of design-based learning on achievement in K-12 education: A meta-analysis. *Journal Of Research In Science Teaching*, 60(2), 330–356. <https://doi.org/10.1002/tea.21800>
- Delen, I., & Uzun, S. (2018). Evaluating STEM Based Learning Environments Created by Mathematics Pre-Service Teachers. *Hacettepe University Journal Of Education*, 33(3), 617–630. <https://doi.org/10.16986/HUJE.2018037019>
- Demircan, H. O. (2022). “How am I supposed to do this on my own?{’}”: A case study on perspectives of preschool teachers regarding integrative STEM practices. *Journal of Early Childhood Research*, 20(1), 93–112. <https://doi.org/10.1177/1476718X211052749>
- Donmez, I. (2021). Impact of Out-of-School STEM Activities on STEM Career Choices of Female Students. *Eurasian Journal Of Educational Research*, 91, 172–202. <https://doi.org/10.14689/ejer.2021.91.9>
- Dönmez, İ. (2020). STEM motivasyon ölçeğinin Türkçeye uyarlanması: Geçerlik ve güvenirlik çalışması. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 17(1), 486-510. <https://doi.org/10.33711/yyuefd.693825> *TR Indexed
- Durak, H. Y., Uslu, N. A., Bilici, S. C., & Guler, B. (2022). Examining the predictors of TPACK for integrated STEM: Science teaching self-efficacy, computational thinking, and design thinking. *Education And Information Technologies*. <https://doi.org/10.1007/s10639-022-11505-7>
- Ergun, A., & Balcin, M. D. (2019). The Perception of Engineers by Middle School Students through Drawings. *Eurasian Journal Of Educational Research*, 83, 1–28. <https://doi.org/10.14689/ejer.2019.83.1>
- Ergun, A., & Kiyici, G. (2019). The effect of design based science education applications of science teacher candidates on their perceptions of engineering education and engineer. *Pegem Eğitim Ve Öğretim Dergisi*, 9(4), 1031–1061. <https://doi.org/10.14527/pegegog.2019.033>
- Erkol, M., Artun, H., Temur, A., & Okur, M. (2022). The effect of 3E, 5E and STEM supported learning environment on sustainable development. *Journal of Computer and Education Research*, 10(19), 2148-2896. *TR Indexed
- Ertem Akbaş, E., Cancan, M. & Balcı, F. (2019). Ortaokul öğrencilerinin FeTeMM (Fen-Teknoloji-Mühendislik-Matematik) alanlarına yönelik ilgilerinin çeşitli değişkenlere göre incelenmesi.



- Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 16 (1), 1370-1401. Retrieved from <https://dergipark.org.tr/tr/pub/yyuefd/issue/50700/661086>
- Gencer, A. S., & Dogan, H. (2020). The Assessment of the Fifth-Grade Students Science Critical Thinking Skills through Design-Based STEM Education. *International Journal Of Assessment Tools In Education*, 7(4), 690–714. <https://doi.org/10.21449/ijate.744640>
- Gencer, A. S., Dogan, H., & Bilen, K. (2020). Developing biomimicry STEM activity by querying the relationship between structure and function in organisms. *Turkish Journal Of Education*, 9(1), 64–105. <https://doi.org/10.19128/turje.643785>
- Gok, T. (2021). The determination of high school students' attitudes towards stem. *Mier-Journal of Educational Studies Trends and Practices*, 11(1), 137–159. <https://doi.org/10.52634/mier/2021/v11/i1/1755>
- Gul, K. S., & Ates, H. (2022). An examination of the effect of technology-based STEM education training in the framework of technology acceptance model. *Education And Information Technologies*. <https://doi.org/10.1007/s10639-022-11539-x>
- Guleryuz, H., & Dilber, R. (2022). Robotic coding and 3D printer with STEM activities; the effect of science teacher candidates on STEM awareness and STEM self-efficacy. *Education And Information Technologies*. <https://doi.org/10.1007/s10639-022-11257-4>
- Gunbatar, M. S., & Bakirci, H. (2019). STEM teaching intention and computational thinking skills of pre-service teachers. *EDUCATION AND INFORMATION TECHNOLOGIES*, 24(2), 1615–1629. <https://doi.org/10.1007/s10639-018-9849-5>
- Gunbatar, S. A., Oztay, E. S., & Kiran, B. E. (2022). Supporting pre-service teachers' integration of engineering into STEM lessons throughout engineering-infused training. *RESEARCH IN SCIENCE \& TECHNOLOGICAL EDUCATION*. <https://doi.org/10.1080/02635143.2022.2121691>
- Guyen, G., Cakir, N. K., Sulun, Y., Cetin, G., & Guven, E. (2022). Arduino-assisted robotics coding applications integrated into the 5E learning model in science teaching. *Journal Of Research On Technology In Education*, 54(1), 108–126. <https://doi.org/10.1080/15391523.2020.1812136>
- Guyenilir, M., & Olcay, M. (2019). Engineering Design Process in Education. *9th International Conference The Future Of Education*, 496–501.
- Gülen, S. & Yaman, S. (2018). Fen bilimleri dersinde argümantasyon süreci ve STEM disiplinlerinin kullanımı; odak grup görüşmesi. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 15(1), 1184-1211. Retrieved from <https://dergipark.org.tr/tr/pub/yyuefd/issue/40566/496247>
- Gülhan, F. & Şahin, F. (2018). Fen bilimleri dersine STEM entegrasyonu etkinliklerinin 5. sınıf öğrencilerinin bilimsel yaratıcılıklarına etkisi. *Sakarya University Journal of Education*, 8(4), 40-59. <https://doi.org/10.19126/suje.423105> *TR Indexed



- Hacettepe STEM & Maker Lab. Retrieved April 17, 2023, from <https://hstem.hacettepe.edu.tr>
- Hacioglu, Y., & Donmez Usta, N. (2020). Digital game design-based STEM activity: Biodiversity example. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 57(1), 1–15. <https://doi.org/10.1080/00368121.2020.1764468>
- Higde, E., & Aktamis, H. (2022). The effects of STEM activities on students' STEM career interests, motivation, science process skills, science achievement and views. *Thinking Skills And Creativity*, 43. <https://doi.org/10.1016/j.tsc.2022.101000>
- Hiğde, E., Keleş, F. & Aktamış, H. (2020). STEM alanlarına ve öğretimine yönelik tutumları inceleyen model çalışması. *Bolu Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 20(2), 1145-1160. *TR Indexed
- Ince, E. Y., & Koc, M. (2021). The consequences of robotics programming education on computational thinking skills: An intervention of the Young Engineer's Workshop (YEW). *Computer Applications In Engineering Education*, 29(1), 191–208. <https://doi.org/10.1002/cae.22321>
- Johnston, A. C., Akarsu, M., Moore, T. J., & Guzey, S. S. (2019). Engineering as the integrator: A case study of one middle school science teacher's talk. *Journal Of Engineering Education*, 108(3), 418–440. <https://doi.org/10.1002/jee.20286>
- Kacan, S. D., & Sahin, F. (2018). Analysis of Science Teacher Candidates' Relation between Scientific Creative Thinking Skills, Creative Problem Solving and Project Development Skills. In E. Masal, I. Onder, H. Caliskan, & S. Besoluk (Eds.), *Erpa International Congresses On Education 2018 (Erpa 2018)* (Vol. 48). <https://doi.org/10.1051/shsconf/20184801059>
- Kalkınma Bakanlığı[KB]. (2013). Onuncu kalkınma planı (2014-2018).
- Kalyenci, D., Metin, S., & Basaran, M. (2022). Test for assessing coding skills in early childhood. *Education And Information Technologies*, 27(4), 4685–4708. <https://doi.org/10.1007/s10639-021-10803-w>
- Karabolat B., Atıcı T. ve Taflı, T. (2021). Biyoloji Dersi Öğretim Programında ve Ders Kitaplarında Yer Alan Kazanımların ve Etkinliklerin STEM Yaklaşımına Göre İncelenmesi. *Mehmet Akif Ersoy Eğitim Fakültesi Dergisi*, 58, 645 – 670.
- Karademir Coşkun, T., Alakurt, T. & Yılmaz, B. (2020). Bilişim teknolojileri öğretmenlerinin perspektifinden STEM eğitimi. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, 20 (2), 820-836. *TR Indexed
- Karaduman, B ve İnanç, E (2023). Herkes için STEM: Bir STEM eğitim merkezinde görev yapan eğitim personelinin STEM eğitimine ilişkin görüşleri. *Trakya Eğitim Dergisi*, 13(1), 209-225.
- Karamustafaoglu, O., & Pektas, H. M. (2022). Developing students' creative problem solving skills with inquiry-based STEM activity in an out-of-school learning environment. *Education And Information Technologies*. <https://doi.org/10.1007/s10639-022-11496-5>



- Kartal, B., & Tasdemir, A. (2021). Pre-Service Teachers' Attitudes towards STEM: Differences Based on Multiple Variables and the Relationship with Academic Achievement. *International Journal Of Technology In Education*, 4(2, SI), 200–228. <https://doi.org/10.46328/ijte.58>
- Kınık Topalsan, A. (2018). Sınıf Öğretmenliği Öğretmen Adaylarının Geliştirdikleri Mühendislik Tasarım Temelli Fen Öğretim Etkinliklerinin Değerlendirilmesi . Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi , 15 (1) , 186-219 . Retrieved from <https://dergipark.org.tr/tr/pub/yyuefd/issue/40566/493847> *TR Indexed
- Kızılay, E., Yamak, H. & Kavak, N. (2019). MotivationscaleforSTEM fields. *Journal of Computer and Education Research*, 7(14), 2148-2896. *TR Indexed
- Kirkic, K. A., & Uludag, F. (2021). STEM attitudes of students as predictor of secondary school technology and design course achievement. *Problems Of Education In The 21st Century*, 79(4), 585–596. <https://doi.org/10.33225/pec/21.79.585>
- Korkmaz, Ö. , Acar, B. , Çakır, R. , Uğur Erdoğan, F. & Çakır, E. (2019). Eğitsel robot setleri ile fen ve teknoloji dersi basit makinalar konusunun ortaokul 7. sınıf öğrencilerinin stem beceri düzeylerine ve derse dönük tutumlarına etkisi. *Eğitim Teknolojisi Kuram ve Uygulama*, 9(2) , 372-391 . DOI: 10.17943/etku.518215 *TR Indexed
- Koyunlu Ünlü, Z. & Dere, Z. (2018). Okul öncesi öğretmen adaylarının hazırladıkları FETEMM etkinliklerinin değerlendirilmesi. *Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi*, 19 (2), 1502-1512. *TR Indexed
- Koyunlu Ünlü, Z. & Dere, Z. (2019). Okul öncesi öğretmen adaylarının FeTeMM farkındalıklarının değerlendirilmesi. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 21(1) , 44-55 . <https://doi.org/10.17556/erziefd.481586> *TR Indexed
- Kumas, A. (2021). Evaluation of logger pro innovative technology supported applications in the scope of stem. *Problems Of Education In The 21st Century*, 79(5), 751–766. <https://doi.org/10.33225/pec/21.79.751>
- Kutlu, E. & Bakırcı, H. (2022) Examination of Eighth Grade Students' views on STEM Supported Science Teaching: Simple Machines Unit. *Journal of Computer and Education Research*, 10(20), 2148-2896 *TR Indexed
- Kuvac, M., & Koc, I. (2022). Enhancing preservice science teachers' perceptions of engineer and engineering through STEM education: a focus on drawings as evidence. *Research In Science & Technological Education*. <https://doi.org/10.1080/02635143.2022.2052038>
- Malcok, B. A., & Ceylan, R. (2022). The effects of STEM activities on the problem-solving skills of 6-year-old preschool children. *European Early Childhood Education Research Journal*, 30(3), 423–436. <https://doi.org/10.1080/1350293X.2021.1965639>



- MEB (2016). Milli Eğitim Bakanlığı, Yenilik ve Eğitim Teknolojileri Genel Müdürlüğü. Erişim adresi: http://yegitek.meb.gov.tr/meb_iys_dosyalar/2016_978-975-11-3989-4_STEM-fenteknoloji-mühendislik-matematik-eğitim-raporu.pdf
- MEB. (2015). Millî Eğitim Bakanlığı 2015–2019 Stratejik Planı.
- MEB. (2016). Milli Eğitim Bakanlığı STEM Eğitimi Raporu.
- MEB. (2018). Milli Eğitim Bakanlığı 2023 Eğitim Vizyonu Belgesi.
- MEB. (2019). Milli Eğitim Bakanlığı PISA 2018 Türkiye Ön Raporu.
- Meral, M. & Altun Yalçın, S. (2022). The effect of entrepreneurship-based STEM education on secondary school students' self-regulation skills. *Sakarya University Journal of Education*, 12(1), 150-162. <https://doi.org/10.19126/suje.1023729> *TR Indexed
- Muğla Sıtkı Koçman University Science Education Research & Application Center. Retrieved April 17, 2023, from <https://mubem.mu.edu.tr/tr>
- Mumcu, F., Uslu, N. A., & Yildiz, B. (2023). Teacher development in integrated STEM education: Design of lesson plans through the lens of computational thinking. *Education And Information Technologies*, 28(3), 3443–3474. <https://doi.org/10.1007/s10639-022-11342-8>
- Nağaç, M. & Kalaycı, S. (2021). The effect of STEM activities on students' academic achievement and problem solving skills: Matter and heat unit. *e-Kafkas Journal of Educational Research*, 8(3), 480-498. <https://doi.org/10.30900/kafkasegt.964063>
- Ozcakir Sumen, O., & Calisici, H. (2022). The effects of STEM activities applied in mathematics courses for elementary pre-service teachers in Türkiye. *International Journal Of Mathematical Education In Science And Technology*, 53(12), 3352–3376. <https://doi.org/10.1080/0020739X.2021.1944679>
- Ozcan, H., & Koca, E. (2019). The Impact of Teaching the Subject "Pressure" with STEM Approach on the Academic Achievements of the Secondary School 7th Grade Students and Their Attitudes Towards STEM. *Eğitim Ve Bilim-Education And Science*, 44(198), 201–227. <https://doi.org/10.15390/EB.2019.7902>
- Ozdinc, F., Kayab, G., Mumcu, F., & Yildiz, B. (2022). Integration of computational thinking into STEM activities: an example of an interdisciplinary unplugged programming activity. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 59(3), 151–159. <https://doi.org/10.1080/00368121.2022.2071817>
- Ozkan, G., & Topsakal, U. U. (2021). Exploring the effectiveness of STEAM design processes on middle school students' creativity. *International Journal Of Technology And Design Education*, 31(1), 95–116. <https://doi.org/10.1007/s10798-019-09547-z>
- Ozkan, G., & Umdü Topsakal, U. (2021). Investigating the effectiveness of STEAM education on students' conceptual understanding of force and energy topics. *Research In Science*



- \&Technological Education,39(4), 441–460.
<https://doi.org/10.1080/02635143.2020.1769586>
- Ozkul, H., & Ozden, M. (2020). Investigation of the Effects of Engineering-Oriented STEM Integration Activities on Scientific Process Skills and STEM Career Interests: A Mixed Methods Study. *Egitim Ve Bilim-Education And Science*, 45(204), 41–63.
<https://doi.org/10.15390/EB.2020.8870>
- Özcan, H. & Koştur, H. İ. (2018). Fen bilimleri dersi öğretmenlerinin STEM eğitime yönelik görüşleri. *Sakarya UniversityJournal of Education*, 8(4), 364-373.
<https://doi.org/10.19126/suje.466841> *TR Indexed
- Özçakır Sümen, Ö. & Çalışıcı, H. (2019). STEM proje tabanlı öğrenme ortamında sınıföğretmeni adaylarının geliştirdikleri matematik projelerinin incelenmesi. *OndokuzMayisUniversityJournal of EducationFaculty*, 38 (1), 238-252.
<https://dergipark.org.tr/tr/pub/omuefd/issue/46119/521012> *TR Indexed
- Özkızılcık, M. & Betül Cebesoy, Ü. (2020). Tasarım temelli FeTeMM etkinliklerinin fen bilgisiöğretmen adaylarının problem çözme becerilerine ve FeTeMM öğretimi yönelimlerineetkisinin incelenmesi. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, 33 (1), 177-204<https://doi.org/10.19171/uefad.588222> *TR Indexed
- Öztürk,F.&Özdemir,D. (2020). The effect of STEM educationapproach in scienceteaching: Photosynthesisexperimentexample.*Journal of Computer and Education Research*, 8(16),2148-2896 *TR Indexed
- Pekmez, E. , Yılmaz, H. , Alaçam Akşit, A. C. & Güler, F. (2018). İlköğretim öğrencilerinin fen-teknoloji-tasarım süreci ile ilgili becerilerinin geliştirilmesi üzerine bir eğitim modülü uygulaması. *Ege Eğitim Dergisi*, 19 (1), 135-160. <https://doi.org/10.12984/egeefd.343374> *TR Indexed
- Pişkin Tunç, M. & Gündoğdu, N. S. (2022). Middleschoolstudents' viewsaboutSTEMactivitiesused in teachingratioandproportion. *Bartın UniversityJournal of Faculty of Education*, 11(3), 647-662. *TR Indexed
- Polat, Ö. & Bardak, M. (2019). STEM Approach in Early Childhood in Türkiye. *International Journal of Social Science Research*, 8(2), 18-41.
- Pwc ve Türk Sanayicileri ve İşinsanları Derneği (TUSIAD). (2017). 2023'e Doğru Türkiye'de STEM Gereksinimi.
- Reffiane, F., Sudarmin, Wiyanto, & Saptono, S. (2021). Developing an Instrument to Assess Students' Problem-Solving Ability on Hybrid Learning Model Using Ethno-STEM Approach through Quest Program. *Pegem Egitim Ve Ogretim Dergisi*, 11(4), 1–8.
<https://doi.org/10.47750/pegog.11.04.01>



- Sarıgül, M. & Çınar, S. (2021). Mühendislik Tasarım Odaklı Fen Bilimleri Eğitiminde Öğrencilerin Meslek Tercih ve Algılarındaki Değişim. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, 23 (3), 888-908. <https://doi.org/10.17556/erziefd.885023> *TR Indexed
- Sari, U., Celik, H., Pektas, H. M., & Yalcin, S. (2022). Effects of STEM-focused Arduino practical activities on problem-solving and entrepreneurship skills. *Australasian Journal Of Educational Technology*, 38(3), 140–154. <https://doi.org/10.14742/ajet.7293>
- Sari, U., Pektas, H. M., Sen, O. F., & Celik, H. (2022). Algorithmic thinking development through physical computing activities with Arduino in STEM education. *Education And Information Technologies*, 27(5), 6669–6689. <https://doi.org/10.1007/s10639-022-10893-0>
- Savran Gencer, A. & Doğan, H. (2020). The assessment of the fifth-grade students' science critical thinking skills through design-based STEM education. *International Journal of Assessment Tools in Education*, 7(4), 690-714. <https://doi.org/10.21449/ijate.744640> *TR Indexed
- Savran Gencer, A., Doğan, H. & Bilen, K. (2020). Developing biomimicry STEM activity by querying the relationship between structure and function in organisms. *Turkish Journal of Education*, 9(1), 64-105. <https://doi.org/10.19128/turje.643785> *TR Indexed
- Sen, C., Ay, Z. S., & Kiray, S. A. (2020). A design-oriented STEM activity for students' using and improving their engineering skills: the balance model with 3D printer. *Science Activities-Projects And Curriculum Ideas In STEM Classrooms*, 57(2), 88–101. <https://doi.org/10.1080/00368121.2020.1805581>
- Sisman, B., Kucuk, S., & Yaman, Y. (2021). The Effects of Robotics Training on Children's Spatial Ability and Attitude Toward STEM. *International Journal Of Social Robotics*, 13(2), 379–389. <https://doi.org/10.1007/s12369-020-00646-9>
- Tanik Onal, N., & Saylan Kirmizigul, A. (2022). A Makey-Makey based STEM activity for children. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 58(4), 166–182. <https://doi.org/10.1080/00368121.2021.2011086>
- Tekerek, B. , Aydemir, H. & Tekerek, M. (2023). Robotik ile matematik ve fen entegrasyonu. *Ordu Üniversitesi Sosyal Bilimler Enstitüsü Sosyal Bilimler Araştırmaları Dergisi*, 13 (1) , 25-52 .<https://doi.org/10.48146/odusobiad.1203531> *TR Indexed
- Tekerek, M. & Tekerek, B. (2018). Integrated instructional material and development processes. *Turkish Journal of Education*, 7 (3), 156-168. <https://doi.org/10.19128/turje.362491> *TR Indexed
- Tezcan Şirin, G. , Tüysüz, M. & Kaval Oğuz, E. (2022). Ortaokul fen bilimleri ders kitaplarında yer alan etkinliklerin STEM etkinliklerine uygunluğuna dair öğretmen görüşleri. Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi, Van Yüzüncü Yıl Üniversitesinin Kuruluşunun 40. Yıl



Dönümü Şubat Özel Sayısı, 354-386. *TR

Indexed <https://dergipark.org.tr/tr/pub/yyuefd/issue/68424/1068624>

Timur, B., & Belek, F. (2020). Investigation of the Effects of STEM Activities on Pre-Service Teachers' Self-Efficacy Beliefs and their STEM Intention Levels. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi-Pamukkale University Journal Of Education*, 50, 315–332.
<https://doi.org/10.9779/pauefd.465824>

Timur, S. , Timur, B. , Yalçinkaya Önder, E. & Küçük, D. (2020). Attitudes of the students attending out-of-school stem workshops towards stem education. *Journal of Theoretical Educational Science*, 13 (2), 334-351. <https://doi.org/10.30831/akueg.582388> *TR
Indexed

Tozlu, İ. , Gülseven, E. & Tüysüz, M. (2019). FeTeMM eğitime yönelik etkinlik uygulaması: Kuvvet ve enerji örneği. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, 16(1) , 869-896. <https://dergipark.org.tr/tr/pub/yyuefd/issue/50700/660068> *TR Indexed

Türk Sanayicileri ve İşinsanları Derneği (TUSIAD). (2014). STEM alanında eğitim almış işgücüne yönelik talep ve beklentiler araştırması.

Türk, N. (2019). Eğitim fakültelerinin lisans programlarına yönelik fen teknoloji mühendislik ve matematik (STEM) öğretim programının tasarlanması, uygulanması ve değerlendirilmesi. *Yayınlanmamış Doktora Tezi, Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.*

Türkiye Bilimsel ve Teknik Araştırma Kurumu (TUBITAK). (2010). 2011-2016 Bilim ve Teknoloji İnsan Kaynağı Stratejisi ve Eylem Planı.

Ucgul, M., & Altıok, S. (2022). You are an astronere: the effects of robotics camps on secondary school students' perceptions and attitudes towards STEM. *International Journal Of Technology And Design Education*, 32(3), 1679–1699. <https://doi.org/10.1007/s10798-021-09673-7>

Uğraş, M. (2017). Okul öncesi öğretmenlerinin STEM uygulamalarına yönelik görüşleri. *Eğitimde Yeni Yaklaşımlar*, 1(1), 39–54.

Uğraş, M. & Genç, Z. (2018). Investigatingpreschoolteachercandidates' STEM teachingintentionandtheviewsaboutstemeducation. *Bartın UniversityJournal of Faculty of Education*, 7(2), 724-744. *TR Indexed

Ultay, N., & Aktas, B. (2020). An example implementation of STEM in preschool education: Carrying eggs without breaking. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 57(1), 16–24. <https://doi.org/10.1080/00368121.2020.1782312>

Umutlu, D. (2022). TPACK leveraged: A redesigned online educational technology course for STEM preservice teachers. *Australasian Journal Of Educational Technology*, 38(3), 104–121.
<https://doi.org/10.14742/ajet.4773>



- Uret, A., & Ceylan, R. (2021). Exploring the effectiveness of STEM education on the creativity of 5-year-old kindergarten children. *European Early Childhood Education Research Journal*, 29(6), 842–855. <https://doi.org/10.1080/1350293X.2021.1913204>
- Uslu, S., & Yaman, B. B. (2021). Reflections from the Application of STEM Based Environmental Siphon Activity. *Pamukkale University Journal Of Education*, 53, 457–494. <https://doi.org/10.9779/pauefd.787908>
- Uyar, A. Canpolat, M. ve Şan, İ (2021). STEM merkezindeki öğretmenlerin ve öğrencilerin STEM eğitimi hakkındaki görüşleri: PayaSTEM merkezi örneği. *MANAS Sosyal Araştırmalar Dergisi*, 10(1), 151-170.
- Ürek, H. & Çoramık, M. (2020) A suggestion and evaluation of a STEM activity about friction coefficient for pre-service science teachers. *Journal of Computer and Education Research*, 10(19), 2148-2896. *TR Indexed
- Yabas, D., & Bozoglu, H. S. (2022). A mentorship model for teacher education: Young STEM researchers and practitioners program. *Turkish Journal Of Education*, 11(1), 36–55. <https://doi.org/10.19128/turje.950335>
- Yabaş, D. & Boyacı, S. (2022). A mentorship model for teacher education: Young STEM researchers and practitioners program. *Turkish Journal of Education*, 11(1), 36-55. <https://doi.org/10.19128/turje.950335> *TR Indexed
- Yalcin, V. (2022). Design-Oriented Thinking in STEM education Exploring the Impact on Preschool Children's Twenty-First-Century Skills. *Science & Education*. <https://doi.org/10.1007/s11191-022-00410-7>
- Yaşlık, İ. & Akçay, A. O. (2022). İlkokul 2. sınıf serbest etkinlik dersinde stem etkinliklerinin uygulanması: bir eylem araştırması. *Kırşehir Eğitim Fakültesi Dergisi*, 23(1), 1402-1442. *TR Indexed
- Yazici, Y. Y., Hacıoglu, Y., & Sari, U. (2022). Entrepreneurship, STEM attitude, and career interest development through 6E learning by DeSIGN (TM) model based STEM education. *International Journal Of Technology And Design Education*. <https://doi.org/10.1007/s10798-022-09780-z>
- Yerdelen-Damar, S. , Aksöz, B. , Sezer, S. , Arabacı, N. & Arıkan, F. (2021). Investigating the interrelationships among science and mathematics achievement, attitude towards stem, and gender. *Bartın University Journal of Faculty of Education*, 10(2), 342-357. *TR Indexed
- Yetkin, N. & Aküzüm, C. (2022). İlkokul dördüncü sınıf öğrencilerinin öğrenme anlayışları ve stem eğitime yönelik tutumları arasındaki ilişkinin incelenmesi. *İnsan ve Toplum Bilimleri Araştırmaları Dergisi*, 11 (1), 744-769. *TR Indexed
- Yıldırım, B., & Altun, Y. (2015). STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuvar dersindeki etkilerinin incelenmesi. *El-Cezeri Journal of Science and Engineering*, 2(2), 28-40.



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- Yildirim, B. (2020). A Model Proposal for Teacher Training: STEM Teacher Institutes Training Model. *Pamukkale University Journal Of Education*, 50, 70–98. <https://doi.org/10.9779/pauefd.586603>
- Yildirim, B. (2021). Preschool STEM Activities: Preschool Teachers' Preparation and Views. *Early Childhood Education Journal*, 49(2), 149–162. <https://doi.org/10.1007/s10643-020-01056-2>
- Yildirim, B. (2022). MOOCs in STEM Education: Teacher Preparation and Views. *Technology Knowledge And Learning*, 27(3), 663–688. <https://doi.org/10.1007/s10758-020-09481-3>
- Yildirim, B., & Sidekli, S. (2018). STEM applications in mathematics education: the effect of stem applications on different dependent variables. *Journal Of Baltic Science Education*, 17(2), 200–214.
- Yildirim, B., Akcan, A. T., & Ocal, E. (2022). Teachers' perceptions and stem teaching activities: online teacher professional development and employment. *Journal Of Baltic Science Education*, 21(1), 84–107. <https://doi.org/10.33225/jbse/22.21.84>
- Yorulmaz, A. & Okulu, H. Z. (2022). Sınıf öğretmenleri adaylarının STEM eğitime yönelik inançları, anlayışları ve niyetleri: Bir ölçme aracı uyarlama çalışması. *Batı Anadolu Eğitim Bilimleri Dergisi*, 13(1), 600-617. *TR Indexed
- Yuceler, R., Aydın-Gunbatar, S., & Demirdogen, B. (2020). Stop bridge collapse: a STEM activity about preventing corrosion of metals. *Science Activities-Projects And Curriculum Ideas In Stem Classrooms*, 57(4), 154–164. <https://doi.org/10.1080/00368121.2020.1850408>
- Yucelyigit, S. (2021). Effects of Workshops on the Early Childhood Educators' Perceptions of STEM Practices. *Journal Of Education And Future-Egitim Ve Gelecek Dergisi*, 20, 37–48. <https://doi.org/10.30786/jef.792028>
- Yüksel, A. (2022) Investigation of pre-service scienceteachers' learning experiences on educational robotics applications. *Journal of Computer and Education Research*, 10(19), 2148-2896. *TR Indexed



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