www.ijte.net

Adaptation Studies of Engineering Design Process Cycle to Robotics Coding, STEM, and Nature of Science Activities in Science Education

Nevin Kozcu Cakir
Mugla Sıtkı Kocman University, Turkey

Suna Karlidag
Mugla Sıtkı Kocman University, Turkey

To cite this article:

Kozcu Cakir, N. & Karlidag, S. (2024). Adaptation studies of engineering design process cycle to robotics coding, STEM, and nature of science activities in science education. *International Journal of Technology in Education (IJTE), 7*(3), 550-572. https://doi.org/10.46328/ijte.697

IJTE
International Journal of Technology in Education
2024, Vol. 7, No. 3, 550-572 https://doi.org/10.46328/ijte.697

Adaptation Studies of Engineering Design Process Cycle to Robotics Coding, STEM, and Nature of Science Activities in Science Education

Nevin Kozcu Cakir, Suna Karlidag

Article Info

Article History

Received:
27 November 2023
Accepted:
12 May 2024

Keywords

Science education
Engineering
Robotic coding

Abstract

The purpose of the current study is to examine the effect of adapting the engineering design process to robotic coding, STEM, and the nature of science applications on teachers' self-efficacy towards engineering education and attitudes towards robotic coding. A weak experimental design with a single-group pre-test and post-test, one of the quantitative research methods, was used in the study. The sample of the study consists of 20 science teachers from all over Turkey who meet the application requirements within the scope of the project 2237 supported by TÜBİTAK and working in schools affiliated to the Ministry of National Education. The sample was determined using the purposive sampling method. In this study, teachers were given theoretical and practical training on engineering design process-based STEM, robotic coding, and the nature of science for a total of 36 hours over one week. Quantitative data were analyzed using dependent groups t-test and correlation analysis in the SPSS 23 program. They evaluated their ability to apply these activities in their classes. As a result of the analysis of the quantitative data of the study, it was observed that their self-efficacy towards engineering education and attitudes towards the use of robotic coding in the class showed a positive increase.

Introduction

Science education enables students to approach events in their daily lives with a scientific perspective, learn by doing, solve problems they encounter using 21st-century skills, and as a result, develop 21st-century skills. The most fundamental feature that distinguishes science from other disciplines is its emphasis on experimentation, observation, and exploration (Ministry Education (MEB), 2018). To help students grow up to be literate individuals and be equipped with knowledge and skills, teachers should create rich learning environments in their classrooms. Considering the rapid technological change in the developing and changing world, it has become important to create rich learning environments and use them in classes so that students of this century can catch up with developments. The concept of Industry 4.0 requires to make investments not only in innovative technologies but also in education to train individuals with 21st-century skills. Thus, it is suggested that engineering applications should be incorporated into K-12 science curriculums in innovative teaching programs. In this regard, engineering serves as a bridge for students to the meaningful learning of the content of math and science subjects (Moore, Glancy, Tank, Kersten, Smith, Stohlmann, 2014), helps to develop analytical skills encountered in education through Science, Technology, Engineering and Mathematics (STEM) and underscores the importance of an interdisciplinary holistic approach for training individuals needed in the 21st century (National Academy of Engineering & National Research Council (NAE & NRC), 2009). Therefore, many countries, including the United States, have clearly specified and implemented engineering and engineering design standards in their educational programs (Next Generation Science Standards (NGSS), 2013).

In Turkey, a new science curriculum was put into practice in 2018 (MEB, 2018). In this curriculum, there are examples of innovative practices including the engineering design process, the nature of science, STEM, and robotic coding applications. The importance of the constructivist approach in education is emphasized in the 2018 Science Curriculum. The constructivist learning approach was created by utilizing Piaget's and Vygotsky's learning theories. It is defined as an active process in which the student restructures newly learned information on the basis of their past experiences and knowledge. In this context, learning objectives cannot be achieved with the information presented by teachers alone.

Students should be encouraged to construct the newly-learned information by processing it with their existing personal knowledge and perceptions (Yager, 1991). When the constructivist learning approach is used, rich learning environments can be created where students are active in the process, receive help from their peers and construct the knowledge. In this way, it is thought that students will be able to understand difficult abstract concepts and learn effectively, permanently and meaningfully.

The engineering design skills were incorporated into the 2018 Science Curriculum to integrate STEM disciplines to encourage students to produce solutions to engineering design problems (Wendell, 2008). For STEM, it is sufficient to address two of the disciplines of science, technology, engineering, and mathematics together. In addition, while prototyping, product development, marketing and entrepreneurship skills are not a priority in STEM, developing engineering design skills is a priority. The engineering design cycle process is proposed for the development of engineering design skills. Barnett, Connolly, Jarvin, Marulcu, Rogers, Wendell & Wright (2008) and Wendell, Connolly, Wright, Jarvin, Rogers, Barnett & Marulcu (2010) developed a five-stage model that shows that engineering design process applications for elementary school students progress in a cycle.

Figure 1 shows the steps of the engineering design process recommended by Wendell and colleagues (2010) for the elementary school level. The process covers all the tasks performed by an engineer in the design phase. The process consists of five steps starting with problem identification and ending with product presentation. Although the process is not always as simple as this for engineers, it has been made suitable for students at the elementary school level (Topalaslan, 2018).

Hynes, Portsmore, Dare, Milto, Rogers, Hammer & Carberry (2011) detailed the 5-stage engineering design process cycle for older groups and modeled it as a 9-stage cycle. When Figure 2 is examined, it is seen that in the loop at the center of the figure, the ways an engineer proceeds in the design creation process are explained, and in the loop around it, how to implement activities within the framework of the engineering design process while teaching science lessons throughout a unit is explained. In the model shown in Figure 2, the engineering design process starts with defining the problem and ends with reaching a decision. The engineering design process is not a cycle that moves in a single direction.

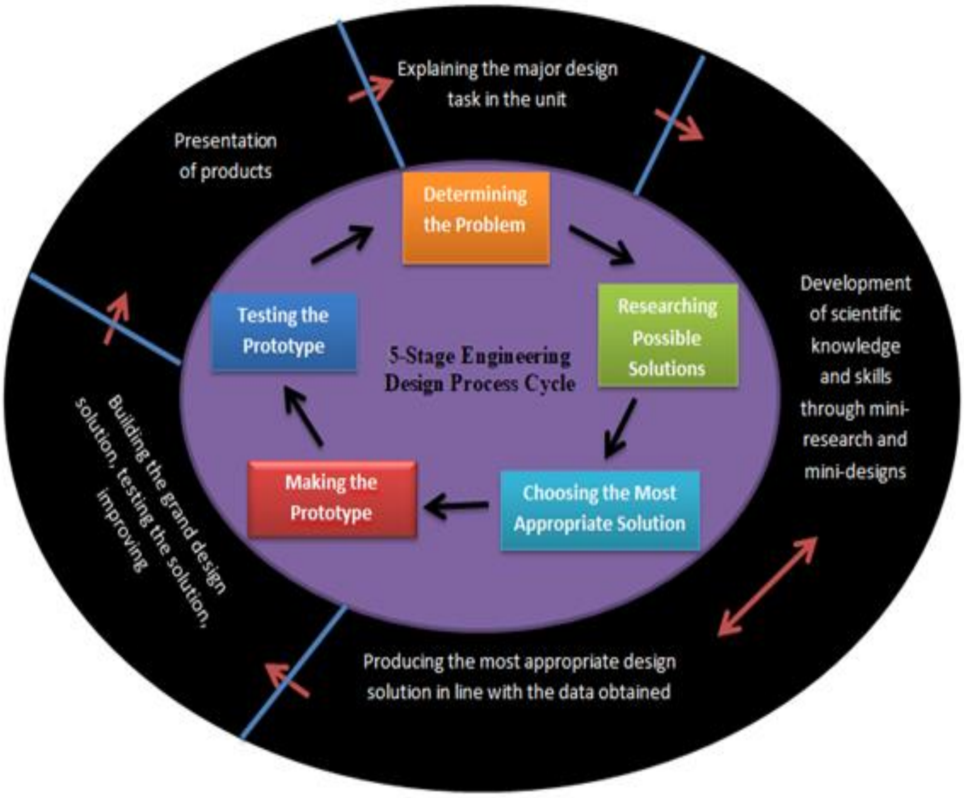

Figure 1. Engineering Design Process (Wendell, K. B., et al. (2010). Incorporating Engineering Design into Elementary School Science Curricula. American Society for Engineering Education. https://dl.tufts.edu/catalog/tufts:18965)

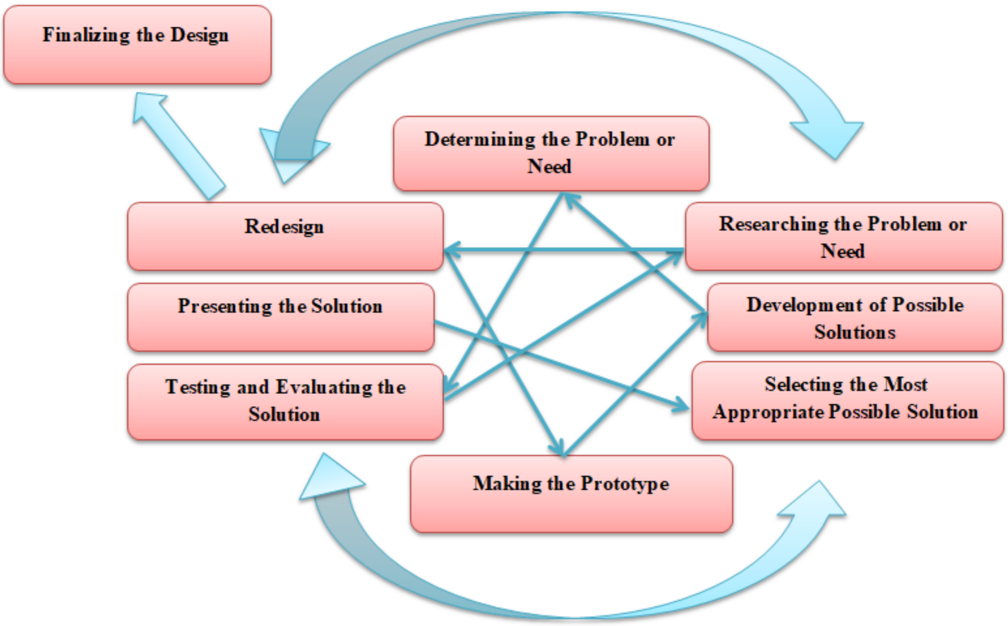

Figure 2. Science Education Cycle that is structured around the Steps of the Engineering Design Cycle (Hynes et. al., 2011)

When we look at the 9-stage engineering and design process cycle shown in Figure 2, it is seen that the student identifies the problem by starting from a need in daily life. Criteria that will lead to the solution of the problem and constraints that will hinder the solution of the problem are determined. In the stage of developing possible solutions, the student develops multiple paths to solution of the problem by using research-inquiry skills. In the stage of selecting the best solution, the student selects the best solution among the identified solutions by using decision-making skills. In the stage of making the prototype, the student prepares a prototype for the design he/she has thought of. In the stage of testing the prototype, the student checks whether the design created solves the problem. If the prototype does not solve the problem, the previous steps are repeated. If the prototype solves the problem, the student presents the prototype he/she has made to his/her classmates in the classroom by using communication, entrepreneurship and marketing skills. After this stage, the design is finalized. All these stages support the development of 21st-century skills of students (creative thinking, problem solving, innovative thinking, dreaming, analytical thinking, decision making, learning by doing, critical thinking, scientific inquiry and scientific process skills, taking responsibility, teamwork, communication, entrepreneurship, career selection, etc.) in the engineering design process (Arik Erdin, 2021; Asal, 2020; Ayar & Ozalp, 2020; Bakirci & Kaplan, 2021; Baran, Canbazoglu-Bilici & Mesutoglu, 2015; Bozkurt, 2014; Cavas, Bulut, Holbrook & Rannikmae, 2013; Daugherty, 2012; Dogan, Savran-Gencer & Bilen, 2017; Ercan, 2014; Ercan & Sahin, 2015; Gunes-Koc & Kayacan, 2018; Hacioğlu, Yamak & Kavak, 2016; Karakaya & Yilmaz, 2021; Kizilkus Bulut, 2019; Kiyici, Canbazoglu-Bilici, Yamak & Kavak, 2022; Kupeli, 2021; Mesutoglu, 2017; Musaoglu, 2020; Oguz-Unver & Okulu, 2022; Ozer & Canbazoglu-Bilici, 2021; Sari & Yazici, 2019; Sarigul & Cinar, 2021; Surmeli, Yildirim, Sevgi & Gocuk, 2018; Tuhtakaya, 2019; Uzel, 2019; Uzel & Canbazoglu-Bilici, 2022; Yurttas, 2021).

Developing knowledge and skills related to engineering applications are directly linked to teachers' competence in their fields. In this respect, ensuring the professional development of teachers and the development of their pedagogical knowledge is crucial. Steps are being taken both nationally and internationally for the professional development for teachers and to integrate engineering into classrooms through in-service training. In Turkey, the professional development of teachers is supported with the in-service training programs offered by the Ministry of National Education and through the projects supported by the European Union and TUBITAK. Webb (2015) emphasized the need for teachers to develop engineering content knowledge and pedagogical content knowledge (PCK) in their professional development in engineering education. In the study conducted by Sargianis et al. (2012), it was found that teachers feel unprepared to teach engineering applications. In-service training provided to teachers was determined to have a positive impact on their professional knowledge (Duncan et al., 2011; Mesutoglu and Baran, 2021; Yoon et al., 2018). In addition, Webb (2015) noted that teachers' self-efficacy perceptions for teaching engineering are weak due to the lack of content knowledge and pedagogical content knowledge in engineering instruction.

Self-efficacy belief refers to the belief of individuals in how well they can perform the actions necessary to cope with the situations they encounter (Bandura, 1977). It is important for students to have high self-efficacy for them to participate in any process, to be productive and to be successful. For students to be able to be effectively involved in the engineering design process, they need to have self-efficacy in the field of engineering (Hacioglu, Yamak & Kavak, 2016; Kizilkus-Bulut, 2019; Meral, Altun-Yalcin, Cakir & Samur, 2022). Studies in the literature show that students who have high self-efficacy are more successful in managing the learning process (Bolat, Korkmaz & Karamustafaoglu, 2021; Erdemir-Yilmaz, 2021; Kasalak, 2017; Kizilkus-Bulut, 2019; Yildiz & Seferoglu, 2021). In science education, the engineering design process can help students develop their self-efficacy (Ercan, 2014; Erdemir-Yilmaz, 2021; Hacioglu et al., 2016; Kizilkus-Bulut, 2019; Sarı & Yazici, 2019; Surmeli et al., 2018). As Boriack (2013) stated, teachers' self-efficacy beliefs appear as a factor directly affecting classroom practices.

In the relevant literature, there is a limited amount of research on teachers’ self-efficacy beliefs in engineering instruction (Vessel, 2011; Yoon et al., 2012; Webb, 2015). Therefore, it is thought that teachers who will implement the engineering design process in their classes should have the required knowledge and skills. Therefore, it is recommended that teachers participate in pre-service training on engineering design-based applications (Bozkurt, 2014; Capobıanco, 2011; Capobianco, 2013; Cuıjck, Keulen & Jochems, 2009; Felıx, 2010; Hacioglu et al., 2016; Marulcu & Sungur, 2012; Yasar, Baker, Robinson-Kurpıus, & Roberts, 2006). In light of all this information, the importance of the engineering design process in science education is understood. The engineering design process can be used on its own or in cooperation with other disciplines. Applications such as the nature of science, STEM and robotic coding can be addressed under the engineering design process. The nature of science, which is the first of these innovative applications, includes values specific to scientific knowledge and the development of scientific knowledge (Abd-El-Khalick & Lederman, 2000; Lederman & Zeidler, 1987). In the science curriculum put into effect by the Ministry of National Education in 2018, the understanding of the nature of science is addressed in the special objectives of the curriculum such as helping to understand how scientific knowledge is created by scientists, which stages should be followed in the creation of this knowledge and how it is used in new research. Through the nature of science activities, students learn what science is, what the stages of scientific knowledge formation are and the fact that knowledge can change over time. They also gain the ability to solve problems in their daily lives (Kucuk, 2016; MEB, 2018).

At the same time, nature of science activities enable students to develop a scientific understanding in their academic lives and structure the nature of science in their minds. When the literature is examined, it is seen that the importance of nature of science activities in science classes is emphasized. In addition, nature of science activities enable the development of cognitive, affective, and psychomotor skills of students and provide opportunities for the development of 21st-century skills such as problem solving, analytical, creative, critical, versatile, innovative thinking, etc. (Keklik, 2019; Kesgin & Timur, 2020; Mihladiz & Dogan, 2017; Ozer, Dogan, Cakmakci, Irez & Yalaki, 2017; Ozcan & Tasar, 2018; Ozgisi, 2022; Prachagool, Nuangchalerm, 2019; Prima, Utari, Chandra, Hasanah & Rusdiana, 2018; Sade-Memisoglu, Ercelik, 2022; Saritas, 2020; Savas, 2020; Tasdere, 2018; Torres, & Vasconcelos, 2020; Yesiloglu, 2021; Yuksel, 2019).

STEM education, is an approach that deals with the fields of science, mathematics, engineering and technology in an integrated way by establishing interdisciplinary relationships (Buyruk & Korkmaz, 2016; Sahin, Ayar & Adiguzel 2014). STEM education aims to train students as individuals who understand the nature of science, think critically, creatively, analytically, solve problems (Baran, Canbazoglu-Bilici, Mesutoglu & Ocak, 2016; Buyruk & Korkmaz, 2016; Childress, 1996; Elliott, Oty, McArthur & Clarck, 2001; Göloglu-Demir, Tanik Onal & Onal, 2021; Kim & Choi, 2012; Tasdemir, 2022; Timur, Timur, Ozturk & Yalcınkaya-Onder, 2022; Tiryaki & Adiguzel, 2021) and relate them to daily life (Choi & Hong, 2013; Sahin et al., 2014; Becker & Park, 2011; Bybee, 2010; Cotabish, Dailey, Robinson & Hughes, 2013). The results of PISA and TIMSS exams show that the science education given in Turkey is not good enough. To achieve better results, many countries have suggested that science education should be given in integration with other disciplines such as mathematics, technology and engineering. According to the results of the 2018 PISA and 2019 TIMSS exams, Turkey has increased its averages in mathematics, science and reading comprehension compared to previous exams, but remained below the average of OECD countries. This increase is thought to be because of the effect of STEM, engineering design and robotic coding included in the 2018 science curriculum.

Robotic coding refers to a technology that enables the creation of relevant devices by adapting electronic circuits to science subjects, the writing of software codes related to those circuits on the computer platform, the operation of the device, and thus makes difficult concepts more understandable. With the integration of robotic coding, students' creativity, problem-solving, versatile thinking, analytical thinking, learning by doing, critical thinking, communication, collaborative learning, and decision-making skills are developed in science courses (Aris & Orcos, 2019; Arslan & Celik, 2022; Caliskan, 2020; Coskunserce, 2021; Demir-Kacan & Kacar, 2022; Guven, 2021; Guven, Kozcu-Cakir, Sulun, Cetin, Guven, 2022; Kozcu-Cakir & Guven, 2019; Tiryaki & Adiguzel, 2021; Yildiz & Seferoglu, 2021). Moreover, students' success in the cognitive domain and their interest, attitude, and motivation towards the course have been observed to develop positively (Datteri, Zecca, Laudisa, Castiglioni, 2013; Guven et al., 2022; Kozcu-Cakir & Guven, 2019; Kozcu-Cakir & Yurdakul, 2021; Sullivan, 2008; Welch & Huffman, 2011). Thus, robotic coding applications can result in significant gains in science education. Therefore, it is necessary to provide students with robotic coding education (Hacioglu, Yamak & Kavak, 2016; Kozcu-Cakir & Guven, 2019). The reason for this may be that students take an active role during robotic coding applications, participate in the learning process by trial and error, and become curious and eager to learn as the lesson becomes fun. Also, robotic coding applications enable students to develop themselves by increasing their interest, attitude and motivation towards science, preparing them for scientific projects and helping them in their future career choices, while allowing the development of skills such as career development, marketing and entrepreneurship in students.

To ensure the development of technology and engineering design skills, it is important to integrate robotic coding applications into engineering design-based science education. Although there are not many studies in the literature on relevant applications, Yurttas (2021) examined the effect of engineering design-based robotic applications on students' daily life-based problem-solving skills and found that students' problem-solving skills improved, the relevant activities contributed positively to their daily lives, and they learned while having fun in class. In this regard, qualified teachers who will apply engineering design-based robotic coding applications are needed to contribute to effective learning of students.

Engineering design-based science education has been provided to science teachers within the scope of the project 2237 supported by TÜBİTAK. The goal of this project is to enable teachers to gain competence in applying the engineering design process, relating it to the nature of science, STEM, and robotic coding in their classrooms. In the engineering design process, the nature of science, STEM and robotic coding applications are important for students to construct knowledge, and for learning in science to be more permanent. When the studies in the literature were examined, it was found that there were very few studies that combined robotic coding and the nature of science with the engineering design cycle, that very few studies were conducted on engineering design applications within the scope of science lessons and that the engineering design process was generally associated only with the STEM field. It is important for students to have interest, attitude, motivation, and self-efficacy towards the nature of science, STEM and robotic coding applications in the engineering design process, to construct scientific knowledge and to gain competence (Alayli, 2021; Balci, 2021; Balci & Korkmaz, 2020; Bicer, Uzoglu & Bozdogan, 2018; Bolukbasi, 2019; Erdemir-Yilmaz, 2021; Kurtulan, 2021; Ozkaya, Bulut & Sahin, 2022; Sahin & Korkmaz, 2020; Yaman, Ozdemir & Akar-Vural, 2018). To do so, it is necessary for teachers who will perform applications in these fields to have the required competence in these fields. Generally, teachers tend to participate in in-service training because they feel inadequate in practice (Bozkurt-Altan & Hacioglu, 2018; Hacioglu et al., 2016; Karakaya, Unal, Cimen & Yilmaz, 2018; Ozcan & Kostur, 2018). Thus, the purpose of the current study is to examine the effect of adapting the engineering design process to robotic coding, STEM and the nature of science applications on teachers' self-efficacy towards engineering education and attitudes towards robotic coding.

The sub-problems related to this are given below:

- Sub-Problem 1: What is the effect of adapting the engineering design process to robotic coding, the nature of science and STEM applications on the self-efficacy of science teachers towards engineering education?
- Sub-Problem 2: Is there a difference in terms of the sub-factors of engineering teaching self-efficacy in adapting robotics coding, the nature of science, and STEM applications to the engineering design process?
- Sub-Problem 3: What is the effect of adapting the engineering design process to robotic coding, the nature of science and STEM applications on science teachers' attitudes towards the use of robotic coding in the class?
- Sub-Problem 4: Is there a difference in the sub-factors of the in-class educational robotic coding attitude scale when adapting the engineering design process to robotic coding, the nature of science, and STEM applications?
- Sub-Problem 5: Is there a correlation between engineering education self-efficacy beliefs and attitudes towards the use of robotic coding in class?

Method

Research Design

In the current study, a single-group pretest-posttest experimental design was used as a quantitative research method. Experimental designs are conducted to reveal cause-effect relationships between variables (Buyukozturk, 2016). Pretest-posttest experimental design compares the pre and post states of single groups, where there is no selective assignment or matching (Fraenkel, Wallen, & Hyun, 2012). The design of the study is given in Table 1.

Table 1. Research Design

Pre Test	Application	Post Test
Attitude Scale Toward Educational Robotic Education In-Class Teaching Engineering Self-Efficacy Scale	Engineering Design Process, Robotic Coding, STEM and the theoretical structure of the nature of science, class-specific application examples for the above three areas in the engineering design process.	Attitude Scale Toward Educational Robotic Education In-Class Teaching Engineering Self-Efficacy Scale

Population and Sample of the Study

The sample of this study consists of 20 science teachers from all over Turkey who meet the application requirements within the scope of the project 2237 supported by TÜBİTAK and are working in schools affiliated to the Ministry of National Education. Participants were determined using the purposive sampling method. The purposive sampling method is used for in-depth research by selecting situations that are appropriate for the purpose of the research and rich in information (Yildirim, 2010). The reason for using this method in this study is that it was conducted with teachers who met the participation requirements within the scope of the project and were selected by the researcher.

Data Collection Tools of the Study

In this study, the ‘Attitude Scale for In-Class Educational Robotics Applications’ developed by Balci and Korkmaz (2020) and the ‘Engineering Teaching Self-Efficacy Scale’ originally named ‘Teaching Engineering Self-Efficacy Scale (TESS)’ developed by Yoon, Evans & Strobel (2014) and adapted into Turkish by Erdemir-Yilmaz (2021) were used.

Attitude Scale for In-Class Educational Robotics Applications

Balci and Korkmaz (2020) developed a 5-point Likert scale (1-Strongly disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly agree) consisting of 3 factors called willingness (20 items), collaboration and problem-solving (7 items) and negative attitude (5 items) and 32 items by conducting validity and reliability studies to determine the attitudes of teachers towards the educational use of robotic coding in the class. The Cronbach Alpha reliability coefficient (α) of the sub-factors of the scale are as follows: α=.762 for the willingness factor, α=.795 for the collaboration and problem-solving factor and α=.806 for the negative attitude factor. Additionally, the total Cronbach Alpha reliability coefficient of the scale is calculated as .735. Therefore, the scale, which is considered reliable and valid, is found to be suitable for use in this study.

Teaching Engineering Self-Efficacy Scale

The scale, originally named Teaching Engineering Self-Efficacy Scale (TESS), was developed by Yoon et al.

(2014) to determine teachers' self-efficacy beliefs in engineering education. The scale was adapted into Turkish by Erdemir-Yilmaz (2021). The 6-point Likert-type scale adapted into Turkish by Erdemir-Yilmaz (2021) consists of 4 factors called Engineering Pedagogical Content Knowledge Self-Efficacy (EPCKS, 6 items), Engineering Discipline Self-Efficacy (EDS, 5 items), Engineering Participation Self-Efficacy (EPS, 4 items), and Engineering Outcome Expectancy Self-Efficacy (EOES, 5 items). The Cronbach Alpha reliability coefficients (α) of the sub-factors of the scale are as follows: α = .903 for Engineering Pedagogical Content Knowledge Self-Efficacy (EPCKS), α = .905 for Engineering Participation Self-Efficacy (EPS), α = .920 for Engineering Discipline Self-Efficacy (EDS), and α = .838 for Engineering Outcome Expectancy Self-Efficacy (EOES). The general Cronbach Alpha reliability coefficient of the Turkish version of the scale is α = .926. Therefore, the scale, which is considered valid and reliable, is suitable for use in the study.

Experimental Procedure

In this study, applications were conducted to show how to integrate the engineering design process to STEM, robotic coding, and the theoretical framework of the nature of science in classroom practices of 20 science teachers over a week. This training lasted a total of 36 hours. Throughout the training, the teachers actively participated in the given training and necessary guidance was provided. The content and schedule of the experimental procedure of the study is given in Table 2.

Table 2. Experimental Procedure of the Study

09.00-12.45	14.00-17.45
1st Day Engineering Design Cycle	Coding Training: Scratch 3.0
2nd Day Educational Robotics: Using Arduino	Engineering Design Cycle process in Science Education: Robotic Coding Application
3rd Day STEM Theoretical Structure	Engineering Design in STEM Education Based Applications
4th Day Nature of Science Theoretical Structure	Engineering Design Cycle process in Science Education: Nature of Science applications
5th Day Robotic Coding, STEM and Nature of Science National Competitions in The Engineering Design Cycle Process	

On the first day of the training, theoretical framework of the engineering design cycle was provided to the teachers during the morning sessions, and practical examples for a specific purpose were demonstrated. The teachers worked in groups and created different designs using the same materials provided to each group for a self-selected engineering problem. In the afternoon, theoretical information about coding, specifically what coding is and how it is done, was given. The interfaces of mBlock programs that work with Scratch 3.0 and Ardunio were introduced, and sample applications were demonstrated for a given scenario. During the morning sessions of the second day, the teachers were given theoretical knowledge about educational robotics, and the use of Arduino was discussed. The structure of Arduino, types of sensors, connection methods, and examples of how to code sensors to work in the mBlock program were provided. In the afternoon, the engineering design cycle process in science education was discussed and activity examples on how robotics coding applications based on the engineering design process can be implemented in the classroom were demonstrated. On the third day, the theoretical framework of STEM education was provided in the morning sessions, followed by practical examples. In the afternoon, engineering design-based applications in STEM education continued. The fourth day focused on providing the theoretical framework of the nature of science, followed by practical applications. In the afternoon, applications related to the nature of science were carried out within the framework of the engineering design cycle. On the fifth day, during the morning sessions, discussions were held about robotics coding, STEM, and the nature of science within the engineering design cycle.

Analysis of the Data

In the study, quantitative data obtained from the attitude scale and the self-efficacy scale were analyzed with SPSS 23 program. First, analyses were made to determine whether the data were normally distributed and the normality assumption was found to be satisfied. Skewness and kurtosis coefficients were examined according to Tabachnick & Fidell (2013). After the normality assumption was satisfied, a dependent groups t-test was performed to determine whether there are significant differences between the pre-test and post-test scores taken from the whole scale and its sub-factors and a correlation analysis was performed to determine the relationship between the two scales.

Findings

In this section, findings related to the sub-problems of the study are presented along with their interpretations made on the basis of the analysis of the scores taken from the self-efficacy scale for engineering education and the robotics and coding attitude scale.

Findings Related to the First and Second Sub-Problems

The data obtained from the self-efficacy scale of engineering education applied to science teachers and its sub-factors before and after the adaptation of the engineering design process to robotic coding, the nature of science, and STEM applications were analyzed with a paired-samples t-test. The relevant findings are presented in Table 3.

Table 3. Paired-Simple t-Test Results for Engineering Teaching Self-Efficacy

Sub-Factors	Pre-Test		Post- Test		t(20)	p	Cohen's d
	M	SD	M	SD			
PCKS	25.65	4.09	31.65	4.03	-4.31	.000	0.96
EDS	24.05	3.39	26.95	2.80	-2.57	.019	0.57
EPS	19.80	2.50	20.90	2.43	-1.38	.184	0.31
EOES	21.95	3.41	24.50	3.49	-2.12	.048	0.47
TOTAL	91.45	11.01	104.00	10.51	-3.17	.005	0.71

Table 3 shows whether the pre-test and post-test self-efficacy scores of the science teachers in engineering education taken from the whole scale and its sub-factors vary significantly. It is seen that the Total [t(20) = -3.17, p<0.05], EPCKS [t(20) = -4.31, p<0.05], MDÖ [t(20) = -2.57, p<0.05] and EOES [t(31) = -2.12, p<0.05] scores show a statistically significant difference while the EPS [t(20) = -1.38, p>0.05] score does not show a significant difference. However, when the means are examined, it is seen that the teachers have improved in the EPS (20.90) sub-factor. The effect size refers to the standard value that shows the magnitude of the effect of the independent variable on the dependent variable. Reference intervals are named as small effect size for d = 0.20, medium effect size for d = 0.50, and large effect size for d = 0.80 by Cohen (1962). Accordingly, when the effect value is examined in the above table, the EPCKS sub-factor has a large effect value; the EDS sub-factor and the total scale have a medium effect value; and the EOES sub-factor has a low effect value.

Findings Related to the Third and Fourth Sub-Problems

The pre-test and post-test scores taken from the attitude scale and its sub-factors by the science teachers were analyzed by using the dependent samples t-test. The relevant findings are presented in Table 4.

Table 4. Paired-Simple t-Test Results for Attitudes towards Robotics Coding

Sub-Factors	Pre-Test		Post- Test		t(20)	p	Cohen’s d
	M	SD	M	SD			
Willingness	78.05	9.55	88.45	10.09	-4.73	.000	1.06
Collaboration and Problem-solving	29.40	3.87	30.90	3.89	-1.47	.158	0.33
Negative Attitude	21.35	4.32	22. 45	4.67	-0.96	.349	0.21
Total	128.80	14.98	141.80	15.46	-3.46	.003	0.77

Table 4 shows whether the pre-test and post-test attitude scores taken by the science teachers from the whole scale and its sub-factors vary significantly. It is seen that the willingness [t(20) = -4.73, p<0.05] and the total [t(20) = -3.46, p<0.05] scores show a significant difference while the collaboration and problem-solving [t(20) = -1.47, p>0.05] and negative attitude [t(20) = -0.96, p>0.05] scores do not show a significant difference. However, although the means in these sub-factors of collaboration and problem-solving do not show a significant difference, the teachers have improved in these sub-factors.

The effect size, which shows the magnitude of the effect of the independent variable on the dependent variable, is called the effect size of the standard value. Reference intervals are named as small effect size for d = 0.20, medium effect size for d = 0.50, and large effect size for d = 0.80 by Cohen (1962). Accordingly, when the effect value in the above table is examined, it is determined that the willingness sub-factor has a large effect value and the total scale has a medium effect value.

Findings Regarding the Fifth Sub-Problem

Correlation analysis was conducted to determine the relationship between engineering teaching self-efficacy beliefs and attitudes towards in-class educational robotic coding after the engineering design-based robotic coding in education, STEM, and the nature of science applications. The findings of the correlation analysis are presented in Table 5.

Table 5. Results of the Correlation Analysis between Engineering Education Self-Efficacy and Attitude towards Robotic Coding

	Engineering Teaching Self-Efficacy		
	Pearson Correlation	Sig. (2-tailed)	N
Robotic Coding	.521*	.019	20

When Table 5 is examined, a positive and moderate relationship is seen between the self-efficacy of science teachers in engineering education and their attitudes towards robotic coding at the .05 significance level (r= .521, p= .019). Considering the coefficient of determination (r2 = 0.27), it can be said that 27% of the total variance in attitudes towards robotic coding applications is due to self-efficacy in engineering education.

Discussion and Conclusion

In the current study, the findings obtained from examining teachers' self-efficacy towards engineering education indicate that their indicate self-efficacy beliefs in their engineering teaching skills increased significantly in the sub-factor, EPCKS. It was observed that the EPCKS sub-factor has a large effect value. It is thought that this increase in belief may be attributed to teachers' growing confidence in conducting engineering design-based activities in their classes (Hacioğlu, Yamak & Kavak, 2016; Sari & Yazici, 2019). In addition, research in the literature emphasizes the significant role of teachers' self-efficacy perceptions on students' learning success (Moore & Esselman, 1992, 1994). In the second sub-factor, EDS sub-factor, it was determined that teachers' beliefs in coping with different student behaviors while applying engineering practices in their classes increased, and it was concluded that the EDS sub-factor had a medium effect value. It can be thought that teachers' beliefs in their self-efficacy of guiding students correctly have increased by thinking about which problems they encounter at each stage by experiencing the engineering design process during the practices (Sari & Yazici, 2019). In the third sub-factor, EOES sub-factor, it was concluded that teachers' beliefs about the impact of students on engineering learning were low and the EOES sub-factor had a low effect value. This may be due to the fact that teachers' beliefs in the effectiveness of engineering practices are low because they are new to engineering practices (Sari & Yazici, 2019). In research conducted on the EPS sub-factor, it was observed that teachers have low beliefs in capturing students' interest while teaching engineering subjects, and no significant difference was detected in this regard. The study conducted by Hacioglu, Yamak, and Kavak (2016) sheds important light on this issue. The difficulties teachers face in attracting interest during the process of teaching engineering are generally associated with the process of familiarizing themselves with engineering disciplines. Teachers who do not receive comprehensive training and support may encounter difficulties in capturing students' interest.

Teachers' self-efficacy towards engineering education is crucial for increasing students' engineering self-efficacy through engineering design activities in their classrooms. It is also likely that students' self-efficacy towards science learning will increase as their engineering self-efficacy increases. When the literature is examined, it is seen that studies that use the engineering design process in science education and discuss its effect on teachers are also available. In Erdemir-Yilmaz's (2021) study, which used the self-efficacy scale for engineering education, the engineering teaching self-efficacy beliefs of science teachers (science, physics, chemistry, biology) working in middle and high schools were examined in terms of different variables (gender, engineering education they have received, engineering teaching experience, branch, school type, location of the school, years of teaching experience and age). The research determined that the engineering teaching self-efficacy beliefs of science teachers varied significantly depending on the variables of receiving engineering education and engineering teaching experience. When other studies in the literature related to the use of the engineering design process in science education are examined, it is generally seen that positive perceptions have been expressed (Capobianco, 2011; Cuıjck, Keulen & Jochems, 2009; Hacioglu, Yamak & Kavak, 2016; Sari & Yazici, 2019).

On the other hand, teachers have concerns about applying the engineering design process in their classrooms. Therefore, they have stated that they stay away from such applications (Capobianco, 2011; Cuıjck, Keulen & Jochems, 2009; Hacioglu, Yamak & Kavak, 2016; Sari & Yazici, 2019). These studies show that teachers' self-efficacy is low in using the engineering design process. In the current study, the trainings given to the teachers were found to have increased the teachers' self-efficacy and their desire to use such applications in their classes. Therefore, it can be suggested that in-service trainings should be given to teachers more for the integration of such applications into science topics in classroom environments.

When the attitudes of teachers towards in-class educational robotic education applications are examined, it has been determined that the attitudes of teachers towards applications related to robotic coding have increased in the first sub-factor, willingness sub-factor, and the willingness sub-factor has been found to have a high effect value. This may be due to their finding robotic activities different (Altun-Yalcin, Kahraman & Yilmazturk, 2020; Coskunserce, 2021). In the second sub-factor, collaboration-problem-solving sub-factor, it was found that teachers' attitudes towards using problem-solving skills to ensure collaboration among groups were low, and no statistical difference was detected. This may be due to the fact that inter-group collaboration cannot be fully achieved during group-based robotic coding applications (Balci & Korkmaz, 2020). In addition, it is thought that there is no difference in the collaboration-problem-solving sub-factor because some teachers are not familiar with robotic coding applications and it is a new area they have learned. No difference was observed in the third sub-factor, negative attitude sub-factor. It can be thought that teachers in general do not have negative attitudes towards the activities. Although there was no difference in the collaboration-problem-solving sub-factor, the post-test scores are higher than the pre-test scores.

When the total score taken from the scale is examined, a significant difference was detected and the effect size of the difference was found to be medium. As a result, it can be argued that the teachers understood that robotic coding applications would help to overcome difficulties in science classes. Also, the reason for these results may be to the provision of a learning environment allowing learning by doing and experiencing, using 21st-century skills, arousing curiosity, fostering enthusiastic participation in activities, using research and inquiry skills, problem-solving, analytical thinking, algorithmic thinking skills. When the relevant literature is examined, it is seen that there are studies showing that teachers' attitudes towards in-class educational robotic education applications have developed positively (Kilinc, 2014; Okkesim, 2014), and that the applications have a positive effect on students' attitudes towards robotic coding (Akdogan, 2020; Altun-Yalcin, Kahraman & Yilmazturk, 2020; Balci & Korkmaz, 2020; Guven, 2021; Kasalak, 2017; Sayin, 2020; Sisman & Kucuk, 2018; Yilmazturk, 2020) and science lessons (Balci & Korkmaz, 2020; Guven, 2021; Yilmazturk, 2020). There are also studies that show that robotic coding applications increase students' interest and motivation (Altun-Yalcin, Kahraman & Yilmazturk, 2020; Guven, 2021; Sisman & Kucuk, 2018).

When the relationship between the self-efficacy scale of engineering education and the attitude scale for in-class educational robotics training applications was examined, a positive and medium correlation was found. Robotic coding applications were carried out in line with the engineering design process. It is believed that the teachers were successful in robotic coding applications due to the increase in their confidence in engineering education. Teachers successfully improved the robotic coding applications and carried out the process of creating their own designs for an engineering problem in light of the knowledge and experience they had gained about the engineering design process. Thus, their attitudes towards robotic coding developed positively. In their study, Kaloti-Hallak, Armony and Ben-Ari (2019) observed that students learned the engineering design process meaningfully during their participation in robotic activities. This study supports the current study demonstrating that robotic coding applications are effective in learning the engineering design process. In the study by Yurttas (2021) on group engineering design-based robotic applications with students, it was concluded that students' problem-solving skills improved, and their attitudes and motivations towards robotic coding also improved. Erdem (2019) concluded that teachers' interest in robotic coding increased, engineers' perceptions of their duties changed, and they gained self-confidence. In the study conducted by Tatlisu (2020) on the effect of problem-based learning on primary school students' problem-solving skills in educational robotics applications, it was concluded that educational robotic coding applications carried out on the basis of engineering design cycle had a great impact on students.

Self-efficacy and attitude are important variables for the effectiveness of science teaching. Menon and Azam (2021) determined the effect of self-efficacy beliefs on science teaching in their study with pre-service science teachers and concluded that self-efficacy plays a significant role in science teaching. In summary, teachers should have self-efficacy and attitudes towards engineering design-based STEM, robotic coding, and nature of science practices to offer an effective science teaching to their students.

In the current study, the teachers understood that the applications they learned would be useful in their lessons and gained the ability to guide their students well. As a result, this study can help teachers in training their students more effectively. Engineering design-based robotic coding, the nature of science, and STEM activities in science education are very important. In order to conduct such activities effectively in science classes, there is a need for qualified teachers. For teachers to be able to successfully implement such activities in their classrooms, their attitudes and self-efficacy should be high. In this study conducted on teachers, it was found that engineering design-based robotic coding, the nature of science, and STEM activities contributed to increasing teachers' awareness, self-efficacy, and attitudes towards these areas.

Recommendations

In light of the findings of the study, following recommendations can be made:

- In addition to the engineering teaching self-efficacy scale and the attitude scale towards robotic coding, a scale related to the nature of science and STEM can be used in further studies,
- Quantitative data can be supported with quantitative data in further studies,
- Conducting studies that have a clear theme of STEM, robotic coding, and the nature of science in engineering design can offer teachers the opportunity to guide these practices in their classrooms,
- In-service training can be provided to teachers for the effective use of the engineering design process.

References

Abd-El-Khalıck, F. & Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: a critical review of the literature. *International Journal of Science Education, 22*(7), 665-701.

Akdogan, E. A. (2020). *The achievements in the curriculum of teachers who teach educational robotic coding courses* (Unpublished master's thesis). Bursa Uludağ University.

Alaylı, A. (2021). *Science teacher training on the use of robotic applications (arduino) in STEM (FeTeMM) approach.* (Unpublished master's thesis). University of Trakya.

Altun-Yalcin, S., Kahraman, S., & Yilmaz, Z. A. (2020). Development and validation of robotic coding attitude scale. *International Journal of Education in Mathematics, Science and Technology (IJEMST), 8*(4), 342-352.

Arik-Erdin, M. (2021). *Development of an aeronautical engineering design unit at the secondary school level: Monitoring engineering design process skills and conceptual learning.* (Unpublished doctoral thesis). Yıldız Technical University.

Aris, N. & Orcos, L. (2019). Educational robotics in the stage of secondary education: empirical study on motivation and stem skills, *Education Sciences, 9(*73); doi:10.3390/educsci9020073

Arslan, S. & Celık, Y. (2022). Primary school teachers' and students' views about robotic coding course, *African Educational Research Journal, 10*(2), 178-189, DOI: 10.30918/AERJ.102.22.018

Asal, R. (2020). *The effect of engineering design-based science teaching on the scientific creativity and critical thinking skills of 4th grade primary school students.* (Unpublished master's thesis). Gazi University.

Ayar, M. C. & Ozalp D. (2020). Evaluation of Engineering Activities on Prosthetic Tails and Bioplastics: 6th Grade Engineering Education Example. *Boğaziçi University Education Journal. Special Issue.*

Bakirci, H. & Kaplan, Y. (2021). Problems and solution suggestions faced by science teachers in the field of engineering and design skills. *Journal of Computer and Education Research, 9* (18), 626-654. DOI: 10.18009/jcer.908161

Balci, H. & Korkmaz, Ö. (2020). Development of the attitude scale towards classroom educational robotics training applications, *Ahmet Keleşoğlu Education Faculty Journal, 2*(1), 84-99.

Balci, H. (2021). *The effect of robotics education on teachers' critical thinking and critical thinking support tendencies and teachers' opinions.* (Unpublished master's thesis). Amasya University.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behaviour change. *Psychological Review, 84,* 191-

215.

Baran, E., Canbazoglu-Bılıcı, S., & Mesutoglu, C. (2015). Science, technology, engineering and mathematics (fetemm) spot development activity, *Journal of Research Based Activity, 5*(2), 60-69.

Baran, E., Canbazoglu-Bılıcı, S., Mesutoglu, C. & Ocak, C. (2016). Moving STEM beyond schools: Students' perceptions about an out-of-school STEM education program. *International Journal of Education in Mathematics, Science and Technology, 4*(1), 9-19. DOI:10.18404/ijemst.71338.

Barnett, M. Connolly, K. G., Jarvın, L., Marulcu, I. Rogers, C., Wendell, K. B., & Wrıght, C. G. (2008). Science through LEGO engineering design a people mover: simple machines. http://www.legoengineering.com/wpcontent/uploads/2013/05/LEcom_Compiled_Packet_Machines_LowRes.pdf sayfasından erişilmiştir.

Becker, K. H. & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education: Innovations and Research. 12*(5&6), 23-37.

Bicer, B. G., Uzoglu, M., & Bozdogan, A. E. (2018). Scale Development Study to Determine Science Teachers' Opinions on STEM. *International Journal of Society Researches, 9*(16). DOI: 10.26466/opus.461791.

Board of Education and Discipline. (2018). Science course curriculum. Ankara: Ministry of National Education.

Bolat, A., Korkmaz, Ö. & Karamustafaoglu, S. (2021). Question Development Self-Efficacy Scale to Measure the High Level Learning Level of Science Teachers: Validity and Reliability. *Kırşehir Faculty of Education Journal, 22*(1), 372- 416.

Bolukbası, G. (2019). *Science teachers' views on integrated science, technology, engineering and mathematics education and activities.* (Unpublished master's thesis). Yıldız Technical University.

Boriack, A. C. (2013). *Teachers' perceptions of effective science, technology, and mathematics professional development and changes in classroom practices*. Texas A&M University..

Bozkurt, E. (2014). *The effect of engineering design-based science education on science teacher candidates' decision-making skills, scientific process skills and perceptions of the process.* (Unpublished doctoral thesis). Gazi University.

Bozkurt-Altan, E. & Hacıoglu, Y. (2018). Examining Problem Situations Developed by Science Teachers to Perform STEM-Focused Activities in Their Lessons. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education (EFMED), 12*(2), 487-507.

Buyruk, B. & Korkmaz, Ö. (2016). STEM Awareness Scale (FFS): Validity and Reliability Study. *Turkish Journal of Science Education. 13*(2), 61-76.

Buyukozturk, Ş. (2016). Pretest-Posttest Control Group Pattern and Data Analysis. In Experimental Designs, (5th ed.) (p. 77). Ankara: Pegem Akademi Publishing.

Bybee, R.W., 2010. Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher, 70*(1), 30-35.

Calıskan, E., (2020). The effects of robotics programming on secondary school students' problem-solving skills. *World Journal on Educational Technology: Current Issues. 12*(4), 217-230. https://doi.org/10.18844/wjet.v12i4.5143

Capobıanco, B. M. (2011). Exploring a science teacher's uncertainty with integrating engineering design: an action research study. *Journal of Science Teacher Education, 22,* 645-660.

Capobıanco, B. M. (2013). *Learning and teaching science through engineering design: insights and implications for professional development*. Association for Science Teacher Education, Charleston, SC.

Cavas, B., Bulut, Ç., Holbrook, J., & Rannıkmae, M. (2013). An engineering-oriented approach to science education: engineering project and its applications. *Journal of Science Teaching, 1*(1). http://fead.org.tr/dergi

Chıldress, V. W. (1996). Does Integration Technology, Science, And Mathematics Improve Technological Problem Solving: A Quasi-Experiment. *Journal of Technology Education, 8*(1), 16–26.

Choı, Y. & Hong, S.H. (2013). “The Development And Application Effects Of Steam Program About 'World Of Small Organisms' Unit in Elementary Science.” *Elementary Science Education, 32*(3), 361-377.

Cohen, J. (1962). The statistical power of abnormal-social psychological research: a review. *The Journal of Abnormal and Social Psychology, 65*(3), 145.

Coskunserce, O. (2021). Implementing teacher-centered robotics activities in science lessons: The effect on motivation, satisfaction and science skills. *Journal of Pedagogical Research, 5*(1), 50-64. http://dx.doi.org/10.33902/JPR.2021067231

Cotabısh, A., Dailey, D., Robinson, A., & Hughes, G. (2013). The Effects of a STEM Intervention on Elementary Students' Science Knowledge and Skills. *School Science and Mathematics. 113*(5), 215-226.

Cuıjck, L. V., Keulen, H. V., & Jochems, W. (2009). *Are primary school teachers ready for inquiry and design based technology education?.* http://www.iteaconnect.org/Conference/PATT/PATT22/Cuijck.pdf (Erişim tarihi: 2013, 10 Ağustos).

Datterı, E., Zecca, L., Laudısa, F., & Castıglıonı, M. (2013). Learning to explain: The role of educational robots in science education, *Themes in Science and Technology Education, 6*(1), 29-38. URL: http://earthlab.uoi.gr/theste

Daugherty, J. (2012). Infusing engineering concepts: Teaching engineering design. *National Center for Engineering and Technology Education*. http://files.eric.ed.gov/fulltext/ED537384.pdf (Erişim tarihi: 2016, 8 Temmuz).

Demir Kacan, S. & Kacar, A. (2022). Looking for problem scenarios with robotic coding: Primary school example in Turkey. *International Journal of Psychology and Educational Studies, 9*(2), 525-538. https://dx.doi.org/10.52380/ijpes.2022.9.2.603

Dogan, H., Savran-Gencer, A., & Bılen K. (2017). Science and engineering practice: a case study on edible and renewable car competition event. *Journal of Research-Based Activity, 7*(2), 62-85.

Duncan, D., Diefes-Dux, H., & Gentry, M. (2011). Professional development through engineering academies: An examination of elementary teachers’ recognition and understanding of engineering. *Journal of Engineering Education, 100*(3), 520-539.

Elliott, B., Oty, K., McArthur, J., & Clark, B. (2001). “The effect of an Interdisciplinary Algebra/Science Course on Students‟ Problem Solving Skills, Critical Thinking Skills And Attitudes Towards Mathematics.” *International Journal of Mathematical Education in Science and Technology*, *32*(6), 811–816.

Ercan, S. (2014). *The use of engineering applications in science education: Design-based science education.* (Unpublished doctoral thesis). Marmara University.

Ercan, S., & Sahin F. (2015). Use of Engineering Applications in Science Education: The Effect of Design-Based Science Education on Students' Academic Achievement. *Necatibey Faculty of Education Electronic*

Journal of Science and Mathematics Education 9(1), 128-164.

Erdem, A. (2019). Robotics training of science and arts center teachers: Suleymanpasa / Tekirdag Case. Journal of Education and Training Studies, 7(7), 50–61. doi:10.11114/jets.v7i7.3943

Erdemir-Yilmaz, D. (2021). *Examining the engineering teaching self-efficacy of science teachers in terms of different variables.* (Unpublished master's thesis). Giresun University.

Felix, A. L. (2010). *Design-based science for STEM Student recruitment and teacher professional developmen*t. Mid-Atlantic ASEE Conference, Villanova University.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). How to design and evaluate research in education (Eight Edition). New York: McGraw-Hill.

Gologlu-Demir, C., Tanik-Onal, N., & Onal, N., (2021). Investigation of middle school students' attitudes towards science, technology, engineering and mathematics (stem) education and determination of the predictors, *Journal of Science Learning, 4*(2).101-112.

Gunes-Koc, R. S., & Kayacan, K. (2018). Determining the opinions of science teachers regarding the engineering and design skills included in the 2018 science curriculum. *Turkish Studies Educational Sciences, 13*(19), 865-881. http://dx.doi.org/10.7827/TurkishStudies.13771

Guven, G. (2021). An investigation of the relationship between science course attitudes and robotics attitudes. *Malaysian Online Journal of Educational Technology, 9*(2), 15-29. http://dx.doi.org/10.52380/mojet.2021.9.2.197

Guven, G., Kozcu-Cakir, N., 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, DOI: 10.1080/15391523.2020.1812136

Hacioglu, Y., Yamak, H., & Kavak, N. (2016). Teachers' Opinions on Engineering Design-Based Science Education. *Bartın University Faculty of Education Journal, 5*(3), 807-830. Doi: 10.14686/buefad.v5i3.5000195411

Hynes, M., Portsmore, M., Dare, E., Milto, E., Rogers, C., Hammer, D., & Carberry, A. (2011). *Infusing engineering design into high school STEM courses. 8 Ağustos 2013 tarihinde* http://ncete.org/flash/pdfs/Infusing%20Engineering%20Hynes.pdf sayfasından erişilmiştir.

Kaloti-Hallak, F., Armoni, M., & Ben-Ari, M. (2019). The Effect of Robotics Activities on Learning the Engineering Design Process. *Informatics in Education, 18*(1), 105-129. DOI: 10.15388/infedu.2019.05.

Karakaya, F. & Yılmaz, M. (2021). Examining the engineering design processes of science high school students. *Mersin University Faculty of Education Journal, 17*(3), 511-534. DOI: 10.17860/mersinefd.993346

Karakaya, F., Unal, A., Cimen, O., & Yilmaz, M. (2018). Science teachers' awareness of the STEM approach. *JRES, 5*(1), 124-138.

Kasalak, İ. (2017). *The effect of robotic coding activities on secondary school students' self-efficacy perceptions regarding coding and student experiences regarding the activities.* (Unpublished master's thesis). Hacettepe University.

Keklik, M. E. (2019). *Examining the effects of nature of science activities on matter and its properties on secondary school students' perceptions of the nature of science.* (Unpublished master's thesis). Sakarya University.

Kesgin, D. & Timur, B. (2020). Pre-service teachers' views on the nature of science. *JRES, 7*(1), 270-299.

Kilinc, A. (2014). *The use of robotic technology in teaching the 7th grade light unit.* (Unpublished master's thesis), Erciyes University.

Kim, G. S. & Choi, S. Y. (2012). “The Effect Of Creative Problem Solving Ability And Scientific Attitude Through The Science Based Steam Program İn The Elementary Gifted Students.” *Elementary Science Education*, *31*(2), 216-226.

Kiyici, G., Canbazoglu-Bilici, S., Yamak, H., & Kavak, N. (2022). Engineering Design-Based Thematic Activities: An Investigation of Pre-Service Science Teachers’ Entrepreneurship Mindsets. *Science Insights Education Frontiers, 11*(2), 1531-1549. Doi: 10.15354/sief.22.or050

Kizilkus-Bulut, E. (2019). *The effect of engineering design-based science teaching on the academic achievement, motivation and self-efficacy beliefs of 7th grade students according to their engineering career preferences.* (Unpublished master's thesis). Caucasus University.

Kozcu-Cakir, N. & Guven, G. (2019) Arduino-Assisted robotic and coding applications in science teaching: Pulsimeter activity in compliance with the 5E learning model, *Science Activities, 56*(2), 42-51, DOI: 10.1080/00368121.2019.1675574.

Kozcu-Cakir, N., Yurdakul, S. (2022). The effect of robotic coding-supported activities for science course on motivation and attitude. *Journal of Education and Training Research, 11*(1),19-26.

Kucuk, A. (2016). *The effect of teaching the nature of science within and outside the Light subject area on 5th grade students' understanding of the nature of science.* (Unpublished master's thesis). Recep Tayyip Erdoğan University.

Kupeli, M. A. (2021). *The effect of engineering design-based activities on 8th grade students' environmental awareness, entrepreneurship perception and skills.* (Unpublished master's thesis). Aksaray University.

Kurtulan, G. (2021). *The effect of in-service applied STEM training on science teachers' self-efficacy beliefs.* (Unpublished master's thesis). Bursa Uludağ University.

Lederman, N. G. & Zeidler, D. L. (1987). “ScienceTeachers’ Conceptions Of The Nature Of Science: Do TheyReallyInfluenceTeacherBehavior?” *Science Education, 71*(5), 721-734.

Marulcu, İ. & Sungur K. (2012). Examining science teacher candidates' perceptions of engineers and engineering and their perspectives on engineering-design as a method. *Afyon Kocatepe University Journal of Science, 12,* 13-23.

Menon, D. & Azam, S. (2021). Investigating preservice teachers’ science teaching self-efficacy: An analysis of reflective practices. *International Journal of Science and Mathematics Education, 19*(8), 1587-1607.

Meral, M., Altun Yalcin, S., Cakir, Z., & Samur, E. (2022). Science teachers' views on engineering design practices. *Journal of Innovative Research in Social Studies, 5*(2), 138-154. https://doi.org/10.47503/jirss.1202372.

Mesutoglu, C. (2017). *Developıng teacher learnıng progressıons for k-12 engıneerıng educatıon: teachers’ attıtudes and theır understandıng of the engıneerıng desıgn.* (Yayımlanmamış doktora tezi). Orta Doğu Teknik Üniversitesi.

Mesutoglu, C., & Baran, M. (2021). Effects of In-Service Training on Teachers' Competence in Engineering Education. Journal of Educational Technology, 20(3), 112-125.

Mihladiz, G. & Dogan, A. (2017). Investigation of science teacher candidates' pedagogical content knowledge on the nature of science. *Hacettepe University Faculty of Education Journal, 32*(2), 380-395. Doi:

10.16986/HUJE.2016017220

Ministry of Education (MEB). (2018). Science course curriculum (Primary and Secondary School 3rd, 4th, 5th, 6th, 7th and 8th grades). Ankara: National Education Publications.

Moore, W. P. & Esselman, M. E. (1992). *Teacher efficacy, empowerment, and a focused instructional climate: Does student achievement benefit?* Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Moore, W. P. & Esselman, M. E., (1994). *Exploring the context of teacher efficacy: The role of achievement and climate.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Moore, TJ., Glancy, AW., Tank, KM., Kersten, JA., Smith, KA. & Stohlmann, MS. (2014). A framework for quality K-12 engineering education: Research and development. Journal of Pre-College Engineering Education Research, 4(1), 1-13.

Musaoglu, G. (2020). *Examination of seventh grade students' engineering design levels and product promotion qualities regarding space pollution in science course.* (Unpublished master's thesis). Recep Tayyip Erdoğan University.

NAE & NRC (National Academy of Engineering and National Research Council), (2009). Engineering in K-12 Education: Understanding the Staus and Improving the Prospects. Washington, DC: National Academies Press.

NGSS Lead States (2013). Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

Oguz Unver, A., & Okulu, H. Z. (2022). Encouraging creative ideas in the engineering design process for science classes. *International Journal of Research in Education and Science (IJRES), 8*(3), 486-501. https://doi.org/10.46328/ijres.2920

Okkesim, B. (2014). *Robotics applications in science and technology education.* (Unpublished Master's Thesis). Erciyes University, Kayseri Erciyes University.

Ozcan, H. & Kostur, H. İ. (2018). Science Teachers' Opinions on STEM Education. *Sakarya University Journal of Education, 8*(4), 364-373.

Ozcan, H., & Tasar, M. F. (2018). Development of a rubric design for evaluating prospective teachers' understanding of the nature of science. *Online Journal of Science Education, 3*(2): 35-46.

Ozer, F., Dogan, N., Cakmakci, G., Irez, S., & Yalaki, Y. (2017). Nature of science content-based activity example: Junk food. *Journal of Research-Based Activity, 7*(2), 93-107.

Ozer, İ. E., & Canbazoglu-Bilici, S. (2021). The effect of engineering design-based algodoo activities on students' design skills and academic achievement. *Hacettepe University Faculty of Education Journal (H. U. Journal of Education) 36*(2), 301-316. Doi: 10.16986/HUJE.2020062006

Ozgisi, M. (2022). *Determining 6th, 7th and 8th grade students' understanding of the nature of science.* (Unpublished master's thesis). Zonguldak Bülent Ecevit University.

Ozkaya, A., Bulut, S., & Sahin, G. (2022). Examining the Effect of STEM Activities on Teachers' Creative Design Skills. Journal of Science, Mathematics, *Entrepreneurship and Technology Education, 5*(1): 1-17.

Prachagool, V., & Nuangchalerm, P. (2019). Investigating understanding the nature of science, *International Journal of Evaluation and Research in Education, 8*(4), 719-725. DOI: 10.11591/ijere.v8i4.20282.

Prima, E.C., Utari, S., Chandra, D.T., Hasanah, L., & Rusdiana, D. (2018). Heat and temperature experiment designs to support students' conception on nature of science. *Journal of Technology and Science Education,* 8(4), 453-472. https://doi.org/10.3926/jotse.419.

Sade-Memisoglu, A. & Ercelik, B. (2022). Determining pre-service science teachers'perceptions of science, nature of science and the relationship between them. *International Journal of Contemporary Educational Research, 9*(2), 378-394. https://doi.org/10.33200/ijcer.1058181.

Sahin, A., Ayar, M.C., & Adiguzel, T. (2014). "After-School Activities Containing Science, Technology, Engineering and Mathematics and Their Effects on Students." *Educational Sciences in Theory and Practice, 14*(1), 297-322.

Sahin, H. & Korkmaz, Ö. (2020). A self-efficacy perception scale development study for teachers regarding the use of educational robots in the classroom. *Ahi Bilge Education Journal (ABED), 1*(1), 1-14.

Sargianis, K., & Yang, S., & Cunningham, CM. (2012), Effective Engineering Professional Development for Elementary Educators Paper presented at 2012 ASEE Annual Conference & Exposition, June 10-13, San Antonio, USA.

Sari, U. & Yazici, Y. Y. (2019). Science teachers' opinions about science and engineering practices. *International Journal of Social Sciences and Education Research, 5*(2), 157-167. http://dergipark.gov.tr/ijsser

Sarigul, M. & Cinar, S. (2021). Change in students' career preferences and perceptions in engineering design-focused science education. *Erzincan University Faculty of Education Journal, 23*(3), 2148-7510. Doi: 10.17556/erziefd. 885023

Saritas, D. (2020). What Messages a Documentary and Biographical Film Give About the Nature of Science to Prospective Science Teachers? *International Journal of Progressive Education, 16*(2). DOI: 10.29329/ijpe.2020.241.18

Savas, E. (2020). *Examining the effect of hot conceptual change on the understanding of the elements of the nature of science in the teaching of the 7th grade light unit.* (Unpublished doctoral thesis). Balıkesir University.

Sayin, Z. (2020). Determining teachers' tendencies in coding education. *Journal of Instructional Technologies & Teacher Education*, *9*(1), 52-64.

Sisman, B. & Kucuk, S. (2018). Validity and Reliability Study of the Turkish Robotics Attitude Scale for Secondary School Students. *Ege Journal of Education, 19*(1), 284-299.

Sullivan, F. V. (2008). Robotics and science literacy: Thinking skills, science process skills, systems understanding, *Journal of Research in Science Teaching, 45*(3), 373-394.

Surmeli, H., Yildirim, M., Sevgi, Y., & Gocuk, A. (2018). Secondary School Students' Performance and Opinions Towards Activities Based on Engineering Design Process. *Çukurova Üniversitesi Eğitim Fakültesi Dergisi, 47*(2), 844-872. http://dergipark.gov.tr/cuefd

Tabachnick, B. G. & Fidell, L. S. (2013). Using multivariate statistics. (6. Baskı). Pearson.

Tasdemir, F. (2022). Examination of the Effect of Stem Education on Academic Achievement: A Meta-Analysis Study. *Education Quarterly Reviews, 5*(2), 282-298. DOI: 10.31014/aior.1993.05.02.489

Tasdere, A. (2018). *Examining the development of science teacher candidates' pedagogical content knowledge regarding the nature of science.* (Unpublished doctoral thesis). Karadeniz Technical University.

Tatlisu, M. (2020). *The effect of problem-based learning in educational robotic applications on the problem solving skills of primary school students.* (Unpublished master's thesis). Bursa Uludağ University.

Timur, B., Timur, S., Ozturk, K., & Yalcin-Kaya Onder, E. (2022). Hopes and goals of secondary school students towards STEM education and their pseudoscience beliefs. *Journal of Pedagogical Research, 6*(2), 110-131. https://dx.doi.org/10.33902/JPR.202212837

Tiryaki, A. & Adiguzel, S. (2021). The effect of stem-based robotic applications on the creativity and attitude of students. *Journal of Science Learning, 4*(3).288-297

Topalaslan, A. (2018). Evaluation of Engineering Design-Based Science Teaching Activities Developed by Primary School Teacher Candidates. *YYU Faculty of Education Journal, 15*(1), 186-219.

Torres, J. & Vasconcelos, C. (2020). Prospective Science Teachers' Views of Nature of Science: Data from an Intervention Programme. *EURASIA Journal of Mathematics, Science and Technology Education, 16*(1), 1305-8223. https://doi.org/10.29333/ejmste/110783

Tuhtakaya, N. (2019). *Evaluation of science teacher candidates' views on engineering design process applications, engineering skills and scientific creativity.* (Unpublished master's thesis). Mersin University.

Uzel, L. (2019). *Evaluation of the effects of engineering design-based applications carried out in the 6th grade matter and heat unit on students' problem solving and design skills.* (Unpublished master's thesis). Aksaray University.

Uzel, L., & Canbazoglu-Bilici S. (2022). Engineering design-based activities: Investigation of middle school students' problem-solving and design skills. *Journal of Turkish Science Education, 19*(1), 163-179. DOI no: 10.36681/tused.2022.116

Vessel, A. (2011). Teachers' self-efficacy in engineering education. Journal of Science Education, 18(2), 75-88.

Webb, DL. (2015). Engineering professional development: elementary teachers' selfefficacy and sources of self-efficacy. Ph.D. Thesis, Portland State University, Educational Leadership: Curriculum and Instruction, USA.

Welch, A. & Huffman, D. (2011). The effect of robotics competitions on high school students' attitudes toward science. *School Science and Mathematics, 111*(8), 416–424.

Wendell, K. B. (2008). *The theoretical and empirical basis for design-based science instruction for children*. Unpublished Qualifying Paper, Tufts University.

Wendell, K. B., Connolly, K. G., Wright, C. G., Jarvin, L., Rogers, C., Barnett, M., & Marulcu, I. (2010). *Incorporating engineering design into elementary school science curricula.* American Society for Engineering Education Annual Conference & Exposition, Louisville, KY.

Yager, R., (1991). The Constructivist Learning Model Towards Real Form in Science Education. *The Science Teacher, 58*(6), 52-57.

Yaman, C., Ozdemir, A., & Akar Vural, R. (2018). Development of the STEM Applications Teacher Self-Efficacy Scale: A Validity and Reliability Study. *Journal of the Institute of Social Sciences, 5*(2), 93 – 104.

Yasar, S., Baker, D., Robınson-Kurpıus, S., & Roberts, C. (2006). Development of a survey to assess K-12 teachers' perceptions of engineers and familiarity with teaching design, engineering, and technology. *Journal of Engineering Education*, 205-216.

Yesiloglu, S. N. (2021). An investigation of nature of science views of science teachers in project schools in Turkey. *International Journal of Curriculum and Instruction, 13*(3), 3021-3041.

Yildirim, K. (2010). Increasing the quality in qualitative research. *Elementary Education Online, 9*(1), 79-92.

Yildiz, T. & Seferoglu, S. S. (2021). The Effect of Robotic Programming on Coding Attitude and Computational Thinking Skills toward Self-Efficacy Perception, *Journal of Learning and Teaching in Digital Age, 6*(2),101-116. https://dergipark.org.tr/en/pub/joltida

Yilmazturk, M. R. (2020). *The effect of projects carried out using robotic coding in the field of science on the technological pedagogical content knowledge attitudes of teacher candidates.* (Unpublished master's thesis). Burdur Mehmet Akif Ersoy University.

Yoon, J., Lee, S., & Park, H. (2012). The Impact of Engineering Education on Teachers' Self-Efficacy. Journal of Educational Psychology, 30(4), 215-230.

Yoon, S. Y., Evans, M. G., & Strobel, J. (2014). Validation of the teaching engineering self-efficacy scale for k-12 teachers: a structural equation modeling approach. *Journal of Engineering Education, 103*(3), 463-485. Doi: 10.1002/Jee.20049.

Yoon, SY., Kong, Y., Diefes-Dux, HA. & Strobel, J. (2018). Broadening K-8 teachers' perspectives on professional development in engineering integration in the United States. International Journal of Research in Education and Science, 4(2),331–348.

Yuksel, M. (2019*). Opinions of science education 2nd grade teacher candidates about the nature of science.* (Unpublished master's thesis). Kırşehir Ahi Evran University.

Yurttas, S. (2021). *The effect of group engineering design-based robotics applications on students' daily life-based problem solving skills.* (Unpublished master's thesis). Bursa Uludağ University.

Author Information

Nevin Kozcu Cakir
https://orcid.org/0000-0002-7538-7882
Mugla Sıtkı Kocman University
Kotekli/ Mentese/ Mugla
Turkey

Suna Karlidag
https://orcid.org/0000-0001-7269-0619
Mugla Sıtkı Kocman University
Kotekli/ Mentese/ Mugla
Turkey
Contact e-mail: *sunakarlidag110@gmail.com*