

## Research Article

# Implementing teacher-centered robotics activities in science lessons: The effect on motivation, satisfaction and science skills

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In studies on the use of robotic in science education, students are generally expected to design and program robots in specially designed robotic laboratories and during extracurricular activities. Although researchers claim that the student-centered approach and active student participation is more effective, teachers generally have to apply traditional teaching strategies in the field of science education due to the high number of students, a lack of materials, insufficient time and lack of professional teaching skills. Robotics activities can be performed in a traditional classroom environment and within a teacher-centered lesson structure. The aim of this study was to investigate the effect of teacher-centered robotics activities performed in science lessons on students' motivation, to determine their satisfaction with the activities and to collect their opinions about the activities. A parallel mixed-methods design was used for data collection. The results of the study indicated that teacher-centered robotics activities increased the motivation of students to participate in science lessons. Moreover, when the interviews with the students were examined, all of them commented that engaging in robotics activities improved their science skills. In addition, the majority of students were satisfied with the robotics activities and had positive feelings about them, believing that they helped them to learn and were enjoyable and interesting.

Keywords: Robotics; Science education; Teacher-centered activity; Motivation; Satisfaction; Science Skills

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## 1. Introduction

With the decreasing prices of robotic components and the emergence of educational robotic kits, the use of robotics has become more and more common in teaching and learning processes. Robotics can positively affect students' critical thinking and problem-solving skills, especially if they are able to design, code and operate robots for educational purposes (Menekse et al., 2017). Moreover, robotics activities help students develop other skills such as creativity, teamwork and collaboration skills, as well as self-confidence, sociability and the wish to give each other support (Khanlari, 2013). Robotics activities are thought to be a good tool to improve students' 21st century skills (Scaradozzi et al., 2015). In addition, using educational robot-based learning systems in

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classrooms offers a significant advantage for students, by improving their motivation and overall interest in learning (Chin, Hong & Chen, 2014). Being motivated increases the likelihood that they will engage in activities that will help them learn and achieve better results (Schmidt, 2007). Thus, it can be said that robotics activities in lessons positively affect the learning and performance of students.

Robotics activities in the field of science education are generally in the form of extracurricular activities and robotic camps. Moreover, these activities are usually carried out in robotics laboratories where students are expected to construct robots by combining robotics components (Alimisis, 2012). Despite the many advantages provided by the use of robotics activities in science education, there have not been enough studies on integrating robotics activities directly into science lessons (Datteri et al., 2013). Moreover, much of the current literature on effect of robotics activities on students' motivation in science lessons has placed particular emphasis on student-centered (SC) activities. However, especially in teaching basic scientific concepts, the traditional, expository, teacher-centered (TC) approach is still widely applied (Gerstner & Bogner, 2010; Randler & Hulde, 2007). In the traditional method, the content is delivered verbally by the teacher and the student is the passive recipient of the information (Zarotiadou & Tsaparlis, 2000). According to a large number of studies, active and SC instructional methods are superior to TC methods in terms of students' understanding of concepts (Ajewole, 1991; Cohen, 1992; Hockings, 2009), and many researchers claim that the transition from TC teaching approaches to SC teaching approaches is necessary (Prosser et al., 1994). Nevertheless, teachers still have to apply traditional teaching strategies in the field of science education due to the high numbers of students in classrooms, lack of materials and time, and inadequate teaching skills. Moreover, the SC and TC approaches do not contradict each other; they can even improve the quality of teaching when combined properly (Elen et al., 2007).

Robot-supported educational activities, in which students are asked to explain the actions of robots that have been previously programmed by teachers, are often a feature of science classes. In this research, we wanted to further explore the potential of TC robotics activities in science lessons. Such robotics activities, in which students take part as observers and commentators, give students the opportunity to improve their scientific research skills and to engage in metacognitive reflection on fundamental issues concerning scientific research methodologies, including the concepts of explanation, hypothesis and experiment (Datteri et al., 2013). With robotics activities, it is possible to make TC lessons more interesting for students and to enable students to participate more intensely in their learning. While it is almost impossible to implement SC robotics activities in most school settings, TC robotics activities have many advantages and can be easily applied. First, unlike SC activities, TC activities can be carried out in classrooms and there is no need for a specially designed robotics lab. Second, one robot set is sufficient for TC activities, while a large number of sets and a large investment are required for SC activities. Third, SC robotics activities require a lot of time and it is often not possible to allocate this time due to the intensive science curriculum. In addition, in order to perform SC activities, students need to be trained in the programming of robot sets, which is not included in the science curriculum. However, in TC activities, students do not need to code robots, and a short period of training is sufficient for the teacher. Excluding programming from robotics activities means that more focus can be placed on the required learning outcomes of the science course. As a result, it is possible to perform TC robotics activities in a standard school environment, which saves both time and money, and is more effective in achieving educational goals.

In the expository teaching strategy, it is expected that the teacher will give oral examples and then provide students the opportunity to practice what they have just learned. Robotics activities can be used as effective materials for this activity in the course of science lessons. However, there is a relatively small body of literature concerned with the effect of TC robotics activities on students' motivation and satisfaction with regard to science lessons and science skills. It is hoped that the current research will contribute to a deeper understanding of robotics activities in science

lessons. The main aim of this study was thus to investigate the effect of TC robotics activities in science lessons on students' motivation with regard to science lessons, to determine their satisfaction with the activities and to collect their opinions about them.

For this purpose, the following research questions were investigated:

1. Do secondary school students who participate in TC robotics activities in science lessons show a higher level of motivation regarding science lessons than students who do not?
2. Are the students participating in TC robotics activities satisfied with these activities?
3. How do these students perceive these activities?

### 1.1. Theoretical Framework

Robotics activities are used in many different educational settings due to their positive effects. For example, many research studies have investigated the effectiveness of educational robots in school settings (Araújo et al., 2013; Chootongchai et al., 2019; Yıldız, 2020), vocational schools (Alimisis, 2012), early childhood Montessori classrooms (Elkin et al., 2014), STEM classrooms (Kim et al., 2015), extracurricular activities (Julià & Antolí, 2016; Sakata Junior & Olguin, 2011), robotic camps (Somyürek, 2015; Ucgul & Cagiltay, 2014) and in project-based learning activities (Kandlhofer & Steinbauer, 2016) in various lessons. The various methodologies used when deploying robots in education have included discovery learning, collaborative learning, project-based learning, competition-based learning and compulsory learning with using robots in compulsory part of education (Altin & Pedaste, 2013). There are also studies on robotics activities based on blended learning (Jara et al., 2011), experimental learning (Kurkovsky, 2014) and meta-cognitive learning theories (Ishii et al., 2007). All these methodologies are based on a constructivist approach and they require students to actively participate in robotics activities. In order to ensure the active participation of students in robotics activities in school settings, a sufficient number of expensive robotic materials need to be provided (Botelho et al., 2012; Saleiro et al., 2013), the number of students should be low (Goldman et al., 2004) and there should be enough time to devote to them (Lathifah et al., 2019). It is therefore not easy to perform robotics activities in most standard classroom environments.

Nevertheless, the use of robot components in science lessons has emerged as an innovative and effective learning tool in educational processes. Robotics applications in education are mostly used in the STEM field and science lessons (Yolcu & Demirer, 2017). Teachers who want to include activities using robots in their lessons must first have the ability to program and control the components of educational robots. In science lessons, in particular, robotics activities can enrich the content and make it more interesting for students. Units in the science curriculum such as "Force and Motion", "Light and Sound", "Electricity in Our Life", "Matter and Heat" are very suitable for the application of robotics (Koç & Büyük, 2013). Robotics technologies are seen as a suitable tool for science education because they motivate students to participate in the lesson and facilitate the implementation of active learning strategies (Khanlari & Mansourkiaie, 2015). Robotics can be pedagogical applied as a tool for science education using different teaching approaches, such as inquiry learning, problem-solving (Altin & Pedaste, 2013) and project-based learning (Karahoca et al., 2011).

A motivated learner will perform better than a learner without motivation. In this respect, motivation is an important component of instruction. Recently, researchers have shown an increased interest in the effect of robotics activities on students' motivation in science lessons. Bolat (2007) defines students' motivation regarding science learning as a desire to learn about science. Being motivated to learn about and understand science is believed to be a vital part of developing and supporting a lifelong interest in science and developing students' scientific literacy (Caballero-Garcia & Grau-Fernandez, 2019). Students who are motivated to learn science display a high degree of engagement in their tasks and demonstrate interest, curiosity, and enjoyment in science classrooms (Lee & Brophy, 1996). Consequently, the main concern of this research was the effect of robotics activities on students' motivation in science lessons. To this end, a Robotics Satisfaction

Survey and the students' comments were used, in conjunction with interviews, in order to collect in-depth data. According to Keller's ARCS model theory, motivated learning requires four conditions: attention, relevance, confidence, and satisfaction (Keller, 1983). Satisfaction is related to students' positive feelings towards learning activities, and it directly affects motivation. Hence, the students' satisfaction with robotics activities was also included among the topics examined within the scope of the research.

## **2. Method**

### **2.1. Research Design**

In the research, a parallel mixed-methods design was used for data collection. A mixed-methods design can be defined as a combination of qualitative and quantitative methods, approaches and concepts in one study or consecutive studies (Creswell, 2003). Combining two or more research methods with different strengths and weaknesses in one study reduces the likelihood that the researcher will make mistakes (Johnson & Christensen, 2019). In parallel design, qualitative and quantitative data of equal importance are simultaneously collected, combined and used together to answer the research question (Özden & Durdu, 2016). In the current study, qualitative and quantitative data were collected together and then analyzed in a holistic manner. While the attempt was made to answer some of the research questions based solely on qualitative data, qualitative and quantitative data were mostly used together in this process.

### **2.2. Participants**

The participants of this study were 45 sixth-grade students at a secondary school in a small town in Turkey. The study was carried out with a single teacher in order to ensure internal validity. The study group consists of all sixth grade students the teacher attends so the sample size is relatively small. The primary purpose of the research is not to generalize but to better understand relationships that may exist. Therefore, the use of convenience sampling technique has been found appropriate. All the students were 12 years old and they had no past experience with educational robotics sets. Students were in three classes and there are 15 students in each class. Robotic activities were carried out in two of the classes, but not in one. Consequently, 30 of the 45 students were in the experimental group (EG) and 15 were in the control group (CG). Half of the 30 students participating in the activities were girls and half were boys. While TC robotics activities were conducted in the science lessons of the EG students, robotics activities were not included in the lessons of the CG students.

### **2.3. Robotics Activities**

In the scope of the study, robotics activities were carried out using the Mbot robot set and Mblock block-based programming environment in sixth-grade science lessons at a secondary school. Mbot is an educational robot kit for beginners that make robotic activities easy and fun. The kit was prepared in a way to enable students to increase their mechanical skills, experience in control and computer systems and to understand the logic of robotic systems from an early age (Numanoğlu & Keser, 2017). Mblock is programming software that makes robot programming fairly simple. It was developed by Makeblok Company, which also produced Mbot. Mbot is an educational robot kit for beginners that make robotic activities easy and fun. The kit was prepared in a way to enable students to increase their mechanical skills, experience in control and computer systems and to understand the logic of robotic systems from an early age (Numanoğlu & Keser, 2017). Mblock is a programming software that makes robot programming fairly simple. It was developed by Makeblok company, which also produced Mbot. Mblock is a block based programming environment and developed based on MIT's Scratch programming software. Mblock can control Mbot and also be used in programming other Arduino-based robots and boards. Before the robotics activities, the teacher was given a one week of training on the use of Mbot and Mblock. Even a teacher who has no prior knowledge of robot programming can implement these activities

after a short training course. In this study, the robotics activities replaced classic experiments in the science lesson curriculum. The robotics activities carried out within the scope of the research are given in Table 1.

Table 1

*Robotic Activities Performed in Science Lessons within the Scope of the Study*

<i>Activity</i>	<i>Description</i>
Measuring the amount of light	In this activity, the light-measuring sensor of the Mbot robot set is used. The light sensor creates a value between 0 and 1023 according to the light in the environment. This value is instantly displayed on the interactive board. It is explained that we see the objects as dark or light according to the amount of light in the environment.
Measuring the distance of objects	The ultrasonic sensor transmits sound waves and can measure the distance of objects by measuring how long it takes for the waves to return from an obstacle. The ultrasonic sensor can detect obstacles at a distance of between 3 cm and 400 cm. This value is instantly displayed on the interactive board. The speed of sound waves per second is explained to students in this way. Images from this activity are shown in Figure 1.
Avoiding obstacles	In this activity, the ultrasonic sensor of the Mbot robot set is used. When the Mbot encounters an obstacle, it turns right and avoids it. The topic of the reflection of sound is explained with this example.
Tracking objects	An object is placed in front of the Mbot. The Mbot retreats when it is closer than 10cm away, stops if it is between 10 and 20 cm away, and it continues to go straight on if it is more than 20 cm away. With this activity, examples of the reflection of sound and the use of the ultrasonic sensor in daily life are discussed with the students.

The expository teaching strategy was applied in the lessons where the robotics activities were carried out. The activities were thus TC activities, and no students were involved in the developing them. The tasks performed by teachers in the preparing of the activities were:

- a) The teacher determined the learning outcome in the science curriculum that could be explained by robotics activities.
- b) The teacher designed the necessary codes for the activity in the Mblock block-based programming environment.
- c) The teacher ran the codes with the Mbot educational robot kit. This made any necessary corrections to the codes and provided the final form.

Conceptual organizers were presented at the beginning of the lesson about the learning outcomes related to the robotics activity. The main purpose of the conceptual organizers was to form the basis for understanding the new information that was being taught. In this manner, a general framework was provided for the information to be presented in the course, and a structure was created in which specific details relating to the topic could be placed. The basic concepts related to the topics were then explained by the teacher. Finally, robotics activities were carried out to concretely demonstrate the effects of the basic concepts. The robot set executed the commands previously prepared in Mblock software, and thus fulfilled a number of specified tasks. The teacher explained the logic of the robotic component used in these tasks. For example, it was explained that an ultrasonic sensor measures the distance of objects by the reflection of sound waves. The teacher explained the connection between the logic of the robotic component and the science topic learned in that lesson. Later, some of the students were allowed to interact with the Mbot robot set and its task. Finally, the question-answer method was used to ensure the students understood and had integrated the robotics activity and the concepts explained at the beginning of

the lesson. Students were also asked to re-interpret the actions of the robotic set and explain their scientific reasons. The advantages of TC robotics activities performed in the classroom over SC robotics activities performed in the laboratory environment can be listed as follows:

- a) There is no need to establish a separate robotics laboratory for robotics activities. Most schools do not have such a facility anyway.
- b) Only one robot set is sufficient for TC robotics activities.
- c) SC robotics activities require a lot of time. The science curriculum is usually very intensive and time-sensitive and thus not suitable for SC activities. TC activities can be carried out in the same time as any other science experiment.

## 2.4. Data Collection

The Science and Technology Course Motivation (STCM) Scale was applied to the CG and EG before and after the robotics activities. The original scale was developed by Tuan, Chin and Shief (2005). The adaptation of the scale to Turkish was carried out by Başdaş (2007). The STCM Scale consists of 35 items in a five-point Likert-type scale. Items on the scales are scored as 1=strongly disagree, 2=disagree, 3=no opinion, 4=agree and 5=strongly agree. The STCM scale has six motivating factors. These are: self- efficacy, active learning strategies, science learning value, performance goal, achievement goal and learning environment stimulation. The "Robotic Satisfaction Test" (RST) used to measure the students' satisfaction with robotics activities was prepared by Koç (2012) using the tests developed by Silva (2008) and Gibbon (2007). The RST consists of six questions and the questions are Likert-type or closed-ended. The Reliability coefficients of the STCM Scale were computed using Cronbach's alpha. The Cronbach's alpha was 0.80 for pretest and 0.82 for posttest. In the analysis of the RST, only descriptive statistics (frequency and percentage) were used. The reliability coefficient of the test was determined as  $\alpha = 0.80$ .

The qualitative data of the research were collected through semi-structured interviews with 16 students who participated in the activities. The interview form consisted of nine questions. It was created within the framework of the research questions and the opinions of three experts were obtained during the development process. After the interview form was prepared, the opinions of three experts in the field and one language expert were obtained to determine the content validity of the questionnaire, and the survey was finalized in line with the experts' suggestions.

## 2.5. Data Analysis

SPSS 21 software was used in the analysis of quantitative data. In order to determine the statistical method to be applied to the scale, normality assumption was checked. Büyüköztürk (2008) states that if the arithmetic mean, median and mode are close to each other in the distribution of scores, and the skewness - kurtosis values are between -1 and +1, the scores can be said to show a normal distribution and parametric tests can be used. As a result of the analysis, it was determined that the skewness - kurtosis values were within the specified limits and normality was tested with the Shapiro-Wilks test. As a result of the normality tests, it was observed that the data collected from the scale showed normal distribution and parametric statistical methods were used in the analysis of the data. Additionally, the assumption of homogeneity of variances was tested and satisfied via Levene's F test.

Gain score analysis was used to determine whether the difference between the scores obtained from the STCM Scale for the EG and CG students was significant. The level of significance (p-value) was considered statistically significant when the value of  $p < .05$ .

Qualitative content analysis method was used in the analysis of the interview data. First, the audio recordings of the semi-structured interviews with the students were transcribed. Then, content analysis was carried out by both the researcher and an expert. Their interpretations were compared. The reliability of the study was tested after this comparison. The reliability was calculated via Miles and Huberman's (1994) formula [reliability=consensus/(consensus+disagreement)] and 92% agreement was obtained.

### 3. Results

#### 3.1. Motivation for Science Lessons

Independent and paired sample t-tests, gain score analysis and one-way ANOVA tests were performed in order to show the effect of robotics activities on students' motivation for science lessons.

Table 2

*t-test Results for STCM Scale Pretest and Posttest Scores of Control and Experimental Groups*

	Control							Experimental						
	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>T</i>	<i>Df</i>	<i>Sig.</i>	<i>d</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>T</i>	<i>Df</i>	<i>Sig.</i>	<i>d</i>
Pretest	15	3.78	.26	.97	14	.35	.36	30	3.76	.37	2.23	14	.03	.44
Posttest		3.88	.29						3.95	.48				

First, the average of the pretest and posttest scores obtained by the EG and CG students from the STCM and the standard deviations of the distributions were calculated. As can be seen from Table 2, the results of the paired-samples t-test indicated that the EG SCTM scale scores were significantly higher for the posttest ( $M = 3.95$ ,  $SD = .48$ ) than for the pretest ( $M = 3.76$ ,  $SD = .37$ ),  $t(14) = 2.23$ ,  $p < .05$ ,  $d = .44$ . The effect size for this analysis ( $d = .44$ ) was found to very close to Cohen's (1988) convention for a medium effect ( $d = .50$ ). On the contrary, no significant differences were found between the CG SCTM scores for the posttest ( $M = 3.88$ ,  $SD = .29$ ) and pretest ( $M = 3.78$ ,  $SD = .26$ ),  $t(29) = .97$ ,  $p > .05$ ,  $d = .36$ . These results indicate that the individuals in the EG had an increased motivation for science lessons after the robotics activities. There was no significant difference between these two groups in the pretests,  $t = .14$ ,  $p > .05$ ,  $d = .06$ . Additionally, the effect size was perhaps small because the motivation for science lesson scores of the two groups were very close to each other at the beginning of this study (CG:  $M = 3.78$ ,  $SD = .26$ ; EG:  $M = 3.76$ ,  $SD = .37$ ).

Gain score analysis was conducted to analyze the two groups' posttest scores. The EG did not significantly outperformed the CG in terms of overall motivation for science lessons after engaging in the TC robotics activities (CG:  $M_{\text{gain}} = .11$ ,  $SD = .43$ ; EG:  $M_{\text{gain}} = .19$ ,  $SD = .47$ ;  $t = -.57$ ,  $p > .05$ ,  $d = 0.18$ ).

When the six subscales of the STCM scale were further investigated, it was found that the EG had significantly better posttest score than the CG in terms of learning environment stimulation ( $F = 10.823$ ,  $p < .05$ ,  $d = 1.05$ ; see Table 3). On the other hand, one-way ANOVA analysis revealed that no significant difference was evident between the two groups in the pretest and posttest scores for the other five subscales. The "learning environment stimulation" subscale is defined as the learning environment surrounding students, such as the curriculum, class activities, teachers' teaching strategies, and pupil interaction that would influence students' motivation regarding science learning (Tuan, Chin, & Shief, 2005). This subscale explains the changes in motivation that occur due to the activities performed in science lessons, such as robotics activities. Therefore, the findings may imply that the TC robotics activities did not affect the overall motivation for science lessons, but that they did significantly increase the motivation for science lessons related to learning environment stimulation.

#### 3.2. Satisfaction with TC Robotics Activities

In order to determine how satisfied the students were with the robotics activities, data were collected using the RST and semi-structured interviews. The RST test consists of six questions and the first three questions of the test are as follows: "How satisfied were you about the robot applications developed for the scientific experiments?", "Would you be satisfied with the use of robots in other experimental activities?" and "How satisfied were you that using the robots in experimental activities facilitated data collection?" To these first three questions, the students answered that they are mostly "very satisfied" with 80.65% ( $N = 25$ ), 80.65% ( $N = 25$ ) and 58% ( $N = 18$ ) respectively. With their answers to the fourth question, 80.65% ( $N = 25$ ) of the students recommended the use of robotic activities in other classes and lessons. In their answers to the fifth

Table 3  
*One-way ANOVA Analysis Results of STCM Subscale Scores*

Subscales	Test	Group	Mean (SD)	F	Sig.
Self-efficacy	Pretest	Control	3.38 (.42)	.013	.910
		Experimental	3.35 (.92)		
Active learning strategies	Posttest	Control	3.64 (.53)	.281	.599
		Experimental	3.48 (.12)		
	Pretest	Control	4.19 (.46)	.490	.488
		Experimental	4.33 (.71)		
Science learning value	Posttest	Control	4.43 (.56)	.000	.983
		Experimental	4.38 (.67)		
	Pretest	Control	3.80 (.45)	1.036	.314
		Experimental	3.94 (.41)		
Performance goal	Posttest	Control	3.84 (.28)	1.395	.244
		Experimental	3.99 (.44)		
	Pretest	Control	2.30 (.84)	1.157	.288
		Experimental	1.99 (.94)		
Achievement goal	Posttest	Control	2.21 (.97)	.001	.980
		Experimental	2.21 (1.05)		
	Pretest	Control	4.74 (.22)	.537	.468
		Experimental	4.64 (.54)		
Learning environment stimulation	Posttest	Control	4.81 (.21)	1.203	.279
		Experimental	4.65 (.57)		
	Pretest	Control	3.83 (.50)	.109	.742
		Experimental	3.77 (.61)		
	Posttest	Control	3.81 (.52)	10.823	.002*
		Experimental	4.39 (.58)		

\*  $p < .05$

question, 70.97% (N=22) of the students stated that their interest in robotics increased as a result of the robotic activities. In the answers they gave to the last question, 74.19% (N=23) of the students stated that their interest in science lesson increased as a result of the robotic activities.

Furthermore, the students participating in the robotics activities were asked during the semi-structured interviews about their levels of satisfaction.

Table 4  
*Semi-Structured Interview Data on Students' Satisfaction with Robotics Activities*

	f	%
Satisfied with the activities	13	81.4
They helped me learn	5	31.3
Enjoyable	3	18.8
Increased students' contribution to the lesson	2	12.5

According to Table 4, 81.3% of the students (N=13) who participated in the interviews stated that they were satisfied with the activities. In addition, 31.3% (N=5) of the students stated that the robotics activities helped them to learn, 18.8% (N=3) of the students thought that the activities were enjoyable, and 12.5% (N=2) of the students thought that the activities increased their contribution to the science lesson. For instance, interviewee #7 indicated that "It led me to better understand the lesson and sound." Moreover, interviewee #12 thinks that "It was both fun and good." Taken together, these results suggest that the students who participated in robotics activities had a high level of satisfaction with these activities.



### 3.3. Students' Opinions about TC Robotics Activities

Semi-structured interviews were conducted with 16 students in order to gather the students' opinions about TC robotics activities in science lessons. The data collected in the interviews are presented in this section. First, what students learned from robotics activities was revealed from their own perspective. The data obtained are summarized in Table 5.

Table 5

*Semi-Structured Interview Data on Topics That Students Learned*

	<i>f</i>	<i>%</i>
Reflection of sound	11	68.8
Ultrasound	1	6.3
Robot tracking objects	1	6.3
Helping disabled people	1	6.3
New inventions can be made with sound	1	6.3

As presented in Table 5, 68.8% (N=11) of the students stated that they had learned about the reflection of sound at the end of their activities. In addition, one student commented on each of the topics of ultrasound, the robot tracking objects, and helping people with disabilities. Interviewee #7 stated that "Those sound waves crashed into it and returned. I learned this." One of the students (Interviewee #9) talked about disabled people as, "The robot helps disabled people."

On the other hand, students' opinions were taken about the effects of robotics activities on the improvement of their science skills. 100% (N=16) of the students thought that the robotics activities had improved their science skills. As interviewee #2 described "Yes, I learned things about the reflection of the sound." Interviewee #5 explained, "Yes, for example, it made it easier for us to answer the questions you asked." Thus it could be concluded that students think that robotic activities improve their science skills.

Finally, students were asked about the most interesting topics they encountered during the implementation. The results are presented in Table 6.

Table 6.

*Semi-Structured Interview Data on Most Interesting Topics in Robotic Activities*

	<i>f</i>	<i>%</i>
Robot can track objects	9	56.3
The internal structure of the robot	5	31.3
Robot can avoid obstacles	4	25
Measurement of distance with sound	2	12.5

According to the interview results, 56.3% (N=9) of the students stated that the most interesting topic in the robotics activities was that the robot followed objects. According to interviewee #2, "The most interesting thing was that when we moved our feet, the robot came. It was very different, so I was interested." As interviewee #3 commented, "The thing I was most interested in was how sound measures distance."

### 4. Discussion

The first research question in this study sought to determine effect of TC robotics activities on students' motivation for science lessons. The results of this study show that there was a significant increase in motivation for science lessons after the robotics activities. Moreover, students who participated in the robotics activities scored significantly higher in motivation for science lessons than students who did not. Although overall motivation for science lessons did not significantly differ between two groups, the EG's score for the learning environment stimulation factor of the STCM scale was significantly higher than that of the control group and this factor mostly explains the changes that occur due to class activities such as robotics activities. This result explains that the

source of the increase in motivation for science lessons in the students was the robotics activities. The findings of the current study support the previous research. Although very little was found in the literature on the use of robotics activities in TC science lessons (Datteri et al., 2013), there are several reports on the motivational effects of robotics activities in various learning environments. A strong relationship between motivation and robotics activities has been reported in the literature. The use of robotics improves students' motivation in STEM education (Kim et al., 2015; Taylor & Baek, 2018), programming courses (Çınar, 2019; McGill, 2012), foreign language education (Hong et al., 2016) and science education (Chin et al., 2014; Koç & Büyük, 2013; Sáez-López et al., 2019; Park, 2015). On the contrary, some research results did not demonstrate any motivational effects from using robots in the classroom (McWhorter & O'Connor, 2009).

A possible explanation for this might be that students are interested in robotics technologies and find them interesting and enjoyable. Moreover, all of the students were encountering robotics technology for the first time so it was an intriguing and new technology for them. Although short term robotics activities do not have an impact on student learning, they clearly have an impact on students' attitudes, including motivation (Nugent et al., 2010). In summary, these results show that, in line with the positive effect of SC robotics activities determined in previous studies, the TC robotics activities performed here also had a positive impact on motivation.

As an answer to the second question of the study, it was determined that the students were satisfied with the robotic activities. This finding broadly supports the work of other studies in this area linking students' satisfaction with the use of robotics in lessons. In various studies in which robotic technologies were used in lessons, it has been observed that students' satisfaction with robotics activities is at a high level (Chin et al., 2014; Koç, 2012; Liu & Lin, 2010). In addition, it was determined that satisfaction with robotics activities is the most important factor affecting motivation (Chin et al., 2014). Thus, the students' satisfaction with the robotics activities can be seen as the most important reason for the increase in students' motivation regarding science lessons.

These results also reflect those of Sáez-López, Sevillano-García and Vazquez-Cano (2019), and Cameron (2005), who also found that fun, participation and interest in the subject matter increased when robotics activities were used. Although the students only spent a short time with robots and often only had the opportunity to observe them, they seemed to have very positive thoughts about the robotics activities. The students' positive thoughts and interests in robotics activities can be used to increase students' general interest in science lessons.

In addition, the opinions of students on robotic activities were collected as data through semi-structured interviews. Most students stated that reflection of sound was the topics they had learned about at the end of the activities. The robotics activities were designed to teach the topic of "reflection of sound", which is a learning outcome in the science curriculum. It can thus be said that the intended learning outcome of the implementation of robotics activities was realized to a large extent. In line with the present results, previous studies have also demonstrated that robotics activities have positive effect on students' science performance (Karahoca et al., 2011).

One of the results obtained from the semi-structured interviews was that the robotics activities had improved students' science skills. In accordance with the present results, previous studies have demonstrated that robotics activities increase science skills like scientific creativity, science process, problem-solving (Alimisis, 2013; Cavas et al., 2012) and scientific inquiry (Williams et al., 2007). A possible explanation for this might be the association of robotics activities with the science curriculum. The teacher determined the learning outcome in the science curriculum that could be explained by robotics activities and explained this to the students at the beginning of the activities. Students may think that at the end of the activities they learned these subjects well. Thus, students may have come to the conclusion that they will understand science subjects better if they engage in robotics activities. Science topics are composed of abstract concepts that can be difficult to understand. The robotics activities might have reduced the cognitive load of students by embodying in concrete form these difficult-to-understand abstract topics. Another possible

explanation for this result is that the robotics activities introduced students to a new technology that they had not yet encountered. These new experiences of the students may have led them to believe that their science skills had increased.

In the semi-structured interviews, the students also explained the most interesting topics in robotic activities according to their views. These findings suggest that the students were more interested in the concepts that the robot revealed through its actions than its internal structure and components. It is difficult to explain this result, but it might be related to students' ignorance of robotic components. The students were encountering robotic technologies for the first time and were not familiar with robotics components. For this reason, they may have perceived the robotic set as a whole and were not interested in how it was constructed. On the other hand, the robotics activities themselves attracted the attention of the students.

When the findings are analyzed as a whole, it can be seen that the TC robotics activities increased the motivation of the students, that the students' attitudes towards robotics activities were positive, that they developed their science skills, and that they were satisfied with the robotics activities. A possible explanation for this might be that robotics attracted the attention of the students because it is a popular technology that they were encountering for the first time.

## 5. Conclusion and Recommendations

The aim of this paper was to investigate the effect of TC robotics activities in science lessons on students' motivation regarding science lessons and to determine the students' opinions about these activities. The most obvious finding to emerge from this study is that the TC robotics activities increased the motivation of the students. However, when the students' answers in the interviews were examined, all of them commented that the robotics activities also improved their science skills. In addition, the majority of students were satisfied with the robotics activities and they had positive thoughts, including that these activities helped them to learn and were enjoyable and interesting. Taken together, these results suggest that including the TC robotics activities in science lessons had a positive influence on participants' attitudes. Robotics activities can be used in science lessons instead of traditional science experiments and can be easily applied in any classroom environment. These findings contribute in several ways to our understanding of TC robotics activities and provide a basis for how to conduct these activities in science lessons. Although studies in the field of robotics in education generally involve situations in which students design and program robots, robotic technologies can also contribute to the lessons educationally when students are observers or interpreters. In this way, student participation can be increased and the content of a science course can be further visualized and exemplified.

The major limitation of this study is the number of robotics activities. Because students perceived the robotics activities as a separate part of their course, they may not have been able to adequately relate these specific activities to science in general. Students' motivations to learn should thus be investigated again with further studies in which TC robotics activities are used in different lessons throughout the semester. Another limitation of the study is that the developments in student's science skills were evaluated only based on student views. The improvement in students' science skills could be evaluated with a quantitative assessment tool.

There may be various issues in conducting experiments in order to increase interaction in science lessons in the classroom environment; teachers often need to do these experiments in laboratories. However, not all science teachers have the opportunity to use a laboratory. Educational robotics sets can be used as a good auxiliary tool to conduct experiments in the classroom environment. They can act as a tool to show students how to apply science topics in daily life, as well as for traditional science experiments. Teachers who conduct science lessons using a TC approach can deploy robotics activities to increase student engagement and interaction. For this reason, more activities in which robotic components are used should be developed for science lessons. For teachers without any prior knowledge of programming to be able to use these robot sets, a two-week training course is sufficient. This training should thus be added to

undergraduate programs and all science teachers should be equipped with the ability to use robotic sets.

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