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Effect of Robotics Technology in Science Education on Scientific Creativity and Attitude Development

Ayşe KOÇ[1], Uğur BÜYÜK[2]

[1] *Dr., Ministry of National Education, Kayseri-TURKEY, ORCID ID: 0000-0002-8629-0007*
[2] *Prof. Dr., Erciyes University, Kayseri-TURKEY, ORCID ID: 0000-0002-6830-8349*

ABSTRACT
In this research, the effect of experimental applications by using robotics technology in Science and Technology course the "Force and Motion" unit on the level of scientific creativity and scientific attitude of students was investigated. This research was designed according to the quasi-experimental method pre-test post-test design with a control group. In the research that was carried out with the 7th grade students (N=40) studying at a secondary school in Kayseri Province, Turkey. "Scientific Creativity Test" and "Scientific Attitude Scale" were used as data collection tools. At the end of implementation which lasted eight weeks, the quantitative data obtained were evaluated at 0.05 meaningfulness level through SPSS package software. "Mann Whitney U-Test" and "Wilcoxon Signed Ranks Test" were applied as analysis techniques. As a result of the research, while a meaningful difference was found between scientific creativity and scientific attitude pre-test post-test points of the students in the experimental group which robotics technology was used, no difference was found in the control group. Thus, it was found out that robotics developed scientific creativity and scientific attitude level of the students who joined the research by affecting it positively. Therefore, it is recommended that robotics-assisted science laboratory activities should also be planned and implemented in different classes, units or subjects to provide a science teaching with a better quality that supports and improves scientific creativity and scientific attitudes of students.

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Introduction

In the developing world, growing individuals who think, search and are aware of what is happening around gradually becomes more important. Because fast scientific and technological developments require people to become more open to innovation, constructiveness, productivity and creativity (Aydeniz, 2017; OECD, 2016). That's why creativity and creative thinking must be given more emphasis on education. Therefore, creative thinking skill is often emphasized in the general objectives of National Education and special objectives of the Science and Technology course. Teachers of science and technology are expected to acquire students with this quality. In this concept, developing creative thinking skills is aimed in primary education curriculum prepared by the Board of Education and Discipline (MNE, 2017).

Creativity is a concept generally defined as the ability to produce both new (original, unexpected) and appropriate (functional and useful) ideas or products (Sternberg, Lubart, 1996). Scientific creativity is also expressed as producing original and useful ideas or products in the field of science (Sak, Ayas, 2013). When we say scientific creativity in science, the ability to establish relationships about events naturally that other people do not realize, analyzing ideas and evaluating by comparing these ideas with others, practicing a theory or transforming abstract ideas into concrete, practical and successful applications come to mind (Stencel, 1995). When the literature was examined in the researchers studying the level of students' scientific creativity, it was shown that the students who participated in the research could not use their skills such as the ability to produce many ideas and handling events in different respects. Thus, it was seen that they could not develop skills in respect to creativity at the desired level (Alacapınar, 2013), especially in the second grade there was a decline in creative thinking (Alacapınar, 2013; Ayverdi et al., 2012; Ülger, 2014). Therefore, different applications that will ensure scientific creativity appear and develop in students and acquire them with versatile points of view are needed.

On the other hand, the basic objective in science education is not memorizing of students the scientific knowledge about the science, but to have the ability to solve problems that they may come across during their life and to acquire scientific attitude and skills required to be able to reach the knowledge (Çepni, 2019; Loxley et al., 2016). Foundations of scientific thinking and living are laid by these attitudes. Thus, the approach to show scientific attitudes and behaviors against problems faced in the leadership of the science and logic all their life open. However, when the literature is examined; it is seen that the science course is not assessed adequately and efficiently when providing students' scientific attitude and behaviors. Relatedly, science teachers face some problems when providing their students' scientific attitudes and behaviors. According to the results of research fulfilled, some of these problems are; lack of carrying out laboratory applications sufficiently, the absence of an equipped laboratory and lack of time (Demir et al., 2011; Güneş et al., 2013; Küçüköner, 2010). However, nowadays, laboratories are one of the most important environments where scientific creativity, scientific attitude and behaviors are acquired. The laboratory is the place where students gain new knowledge by making observations, thinking, producing versatile ideas and interpreting data (Çepni, Ayvacı, 2019a). Therefore, laboratories must be arranged in the forms which enable students to develop their scientific creativity and scientific attitudes. Nevertheless, when we look at the research; it is seen that necessary importance is not given to laboratories in science courses, laboratories are not used efficiently and existing science laboratories that are being used are inadequate in terms of technological equipment (Ergin et al., 2012; Feyzioğlu et al., 2011b). Moreover, it is considered that traditional kits used in today's laboratories that are out of technology may limit students, prevent them from conducting experiments with an investigative and quizzical approach, and cause too much time loss. Thus, the usage of technological tools and instruments in laboratories gained more importance (Koç, Büyük, 2015).

When studies about the usage of technology in laboratory applications in science education made at an international level are examined; we come across a newer technologic application called "Robotics". Research showed that robotics has a potential effect in students to learn different fields of subjects like science, technology, engineering, mathematics, informatics, etc. in their cognitive development (Alimisis, 2013; Benitti, 2012; Eguchi, 2010), in acquiring many skills like problem solving (Koç, 2019; Li et al., 2016; Menekse et al., 2017) and creative thinking (Avcı, 2017; Baek, Yoon, 2016; Botelho et al., 2012; Chao, 2012; Çavaş et al., 2012; Kırkan, 2018; Nemiro et al., 2017; Siper-Kabadayı, 2019; Sullivan, 2011). Since robotics is an interdisciplinary, practical and applied technological field allowing students to develop their creativity, it is adopted in many schools abroad and it is even given as a separate course under the name *"Robotic Science"* (Riberio, 2009). For this reason, robotics technology was used in the applications of this study.

The most basic problem when a robot is decided to be made is the mechanical design it. The most basic solution for this problem is to make a robot through ready kits. As seen in 'Figure 1' and used in this study Lego Mindstorms NXT robotics education kit was designed by the researchers of the Massachusetts Institute of Technology (MIT) in 2006.

Figure 1

Robotics Education Kit Pieces

The kit includes a central module described as the brain, software having a graphic interface enabling to program this module, sensors (e.g. sensitive to sound, light, distance and touch) and servo motors enabling the robot designed to move. It is possible to perform many science experiments in the Science and Technology course by using this and similar education kits. In particular, physics weighted units like the *"Force and Movement"*, *"Light and Sound"*, *"Electricity in Our Life"*, *"Substance and Heat"*, which are in the curriculum are very suitable for robotics applications. For example, the existence of a linear relationship between the force applied to a mass and the momentum gained by mass can be easily observed and measured by using robotics technology (Koç, Böyük, 2013).

While students have the opportunity to make their products with programmable robotics education kits, they also develop their scientific and creative thinking skills (Danahy et al., 2014; Gauntlett, 2014; Lin et al., 2009; Lin et al., 2012; Liu et al., 2010). Additionally, by this robotics education kit, precise measurements that cannot be reached by traditional experiment kits can be obtained and experiments graphics can be drawn simultaneously, and user-caused measurement errors can be minimized (Koç, 2012; Koç, Büyük, 2015; Okkesim-Akkoç et al., 2019).

By providing the usage of robotics technology in the Science and Technology laboratories actively, it is considered that searching the efficiency of robotic-assisted science laboratories is important in terms of both increasing scientific creativity and developing scientific attitudes. Therefore, the objective of this research is to create a robot technology-assisted laboratory environment where they can actively work intended at solving any problem in the 7th grade Science and Technology course the "Force and Motion" unit, and where they can design and program a robot and investigate the efficiency of this environment in terms of their scientific creativity and scientific attitudes. Answers were sought to the following questions within the frame of this objective:

1- Do the students of control and experimental groups before the instruction;
- Have any meaningful differences between their scientific creativity?
- Have any meaningful differences between their scientific attitudes?

2- Do the students of control group before and after the instruction;
- Have any meaningful differences between their scientific creativity?
- Have any meaningful differences between their scientific attitudes?

3- Do the students of experimental group before and after the instruction;
- Have any meaningful differences between their scientific creativity?
- Have any meaningful differences between their scientific attitudes?

4- Do the students of control and experimental groups after the instruction;
- Have any meaningful differences between their scientific creativity?
- Have any meaningful differences between their scientific attitudes?

Methods

Model of the Research

In this research, pre-test post-test with the control group of the quasi-experimental design was used. The experimental design is described as the research design used to explore the cause and effect relationship between variables (Büyüköztürk, 2016). According to the pre-test post-test control group of quasi-experimental design, data collection tools were applied twice on both experimental and control groups at the beginning and end of the study. It was decided that the applications should be carried out by the researcher as the teacher difference which was an internal validity threat was not wanted to affect the research. Sub-problems of the research were evaluated according to pre-test post-test results obtained from the application.

Study Group

The study group of the research consists of the 7th grade students (N=40) studying at a secondary school in Yemliha Town, Kocasinan District, Kayseri Province. Two experimental groups (N=20) and control (N=20) groups were randomly formed from the study group in the research. The school and the students selected for the application were selected by non-probability convenience sampling way. This sampling method gives speed and practicability to the research (Yıldırım, Şimşek, 2013).

Data Collection Tools

In this research, as data collection tools *"Scientific Creativity Test (SCT)"* and *"Scientific Attitude Scale (SAS)"* were used. *Scientific Creativity Test* was developed by Hu & Adey (2002) to measure creativity in science fields and adapted to Turkish by Kadayıfçı (2008). The test which consists of seven open-cloze questions measures all sub-dimensions of the process (imagining, thinking), character (fluency, flexibility, originality) and product (technical product, science knowledge, science fact, science problem) which are the main dimensions of Hu & Adey's (2002) "Scientific Creativity Structure Model".

Scientific Creativity Test questions which are given in Appendix 1 are about the subjects of unusual usages (Question 1), finding out the problem (Question 2), product development (Question 3), scientific imagination (Question 4), problem solving (Question 5), science experiment (Question 6), and product designing (Question 7). Content validity of the original test applied on 160 English secondary school students by Hu & Adey (2002) was adapted to Turkish in accordance with the dimensions of scientific creativity by Kadayıfçı (2008) by taking the views of 35 science educators and science teachers. Additionally, Kadayıfçı (2008) made a factor analysis to provide the construct validity of the test and he indicated that the test measured one main factor and the factor load of all the questions was over 0.30. The Alpha reliability coefficient of the test developed by Hu & Adey was calculated as 0.89 and the alpha reliability coefficient of the test adapted by Kadayıfçı (2008) was calculated as 0.73. Also, in this research the alpha reliability coefficient was set as 0.80.

Scientific Attitude Scale (SAS) which was developed by Duran (2008) was used to find out the attitudes of the 6th and 7th grade students towards science. This scale is a three-point Likert type and it consists of 19 items. Points that can be taken from the scale that is given in Appendix 2 change between 19 to 57. A pilot study of the scale was carried out by Duran (2008) on total of 185 students. Factor analysis was done for the construct validity of the scale. In the initial phase of the factor analysis whether the data were suitable with the factor analysis was checked by "Kaiser-Meyer-Olkin (KMO) Coefficient" and "Barlett Sphericity Test". Upon the data appeared to be suitable with the factor analysis, exploratory factor analysis was used to examine the construct validity and factor structure of attitude scale, and principal components analysis was used as a factoring technique. In the analyses, common factor variance of the factors on each variable, factor loads of items, explained variance rates and line chart were examined. Factor loads of items were assigned as a minimum of 0.30. Rotated basic components analysis (varimax) was applied to examine the factor structures. The scale consists of four factors which are interest and curiosity, usage, enjoyment and regarding. The first factor explains 12.3%, the second factor explains 11.8%, the third factor explains 11.7%, and the fourth factor explains 9.4% of the total variance. Total variance explained by the four factors is 45%. Content and face validity of the scale was provided in line with expert opinion. Reliability analysis was done through the calculation of Cronbach alpha internal consistency coefficient, and it was calculated as 0.79. Cronbach alpha internal consistency coefficient in the analyses done in the scope of this study was found as 0.82.

Implementation of the Research and Data Collection

The dependent variables of this research are scientific creativity and scientific attitudes of the students. On the other hand, independent variables consist of laboratory activities that take place in the curriculum and robotic-assisted laboratory (RoboLab) activities. In this research, before the implementation, 5 groups that were consisted of 4 individuals among students as a control group (N=20) and experimental group (N=20) and pre-tests were applied. All activities were implemented as science and technology club activities after school programs by the researcher, a science teacher who has a postgraduate education in science education and has studies on robotics. Within the scope of the application first, the subject of robotics and robotics education kits which would be used in activities were introduced with presentations and videos in the experimental group and various robot designs were shown (Figure 2). Then five experimental activities that were shown in 'Table 1' and prepared about the "Force and Motion" unit by the researcher were performed within the scope of *"Robotic-Assisted Science and Technology Laboratory: RoboLab"*.

Figure 2

(a) Examining the Pieces of Robotics Education Kit (b) Line Following Robot Show

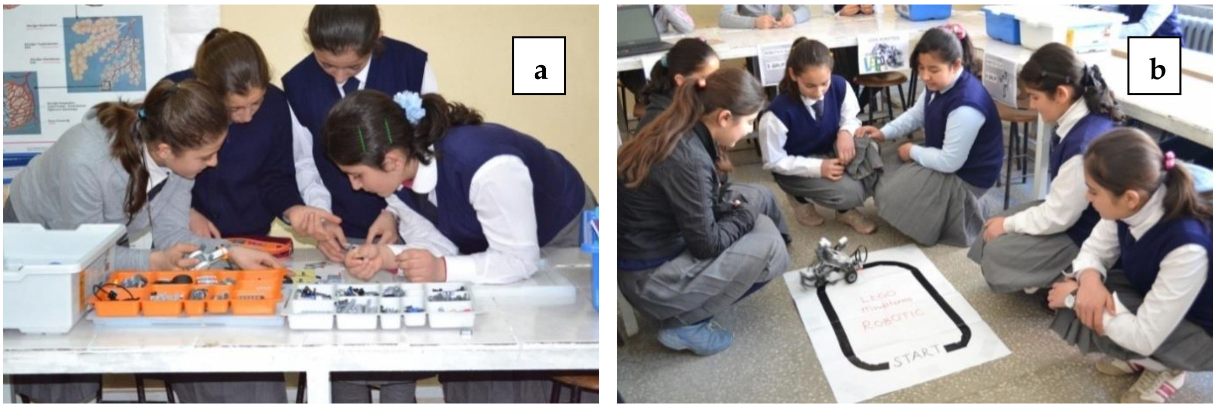


Table 1

Experimental Group RoboLab Activity Program

Week 1	Introduction of Robotics and Robotics Education Kit
Week 2	Implementation of Various Show Activities about Robotics
Week 3	Racing Robots-I (Which is the fastest?) *Robot designing and programming: 30 min., Application-data obtaining: 15 min., Evaluation: 15 min.*
Week 4	RoboDynamometer (Relationship between Weight and Elongation Amount in Bow) *Robot designing and programming: 20 min., Application-data obtaining: 10 min., Evaluation: 15 min.*
Week 5	RoboKinetics (Relationships between Speed-Mass-Kinetic Energy) *Robot designing and programming: 30 min., Application-data obtaining: 15 min., Evaluation: 15 min.*
Week 6	RoboTransformation (Energy Transformation on Inclined Plane) *Robot designing and programming: 30 min., Application-data obtaining: 15 min., Evaluation: 20 min.*
Week 7	Racing Robots-II (Relationships between Force of Friction-Surface-Energy) *Robot designing and programming: 20 min., Application-data obtaining: 15 min., Evaluation: 15 min.*
Week 8	Evaluation of Activities

While developing the activities, firstly the literature was reviewed and international studies on this subject were examined. Considering the suitability of the experimental activities to robotics studies, the "Force and Motion" unit was chosen as the subject area. Then, in line with the unit learning outcomes of the 7th grade Science Course Curriculum, robotic-assisted activities were designed and made ready by submitting to an expert opinion before the application. Accordingly, the students discovered speed-distance-time relationships through robot cars that they designed and programmed in the activity called *"Racing Robots-I"*. They observed the relationship between weight and elongation amount in bow by designing and programming a force metering robot dynamometer in the activity called *"RoboDynamometer"*. They found out the relationship of kinetic energy with speed and mass by putting different pieces of mass on a robot car that they designed in the activity called *"RoboKinetics"*. They moved the Lego robot that they designed in an activity called *"RoboTransformation"* by letting it free on an inclined plane and discovered energy conservation by energy transformation. Finally, different surfaces with different friction coefficients where a robot would move in an activity called *"Racing Robots-II"* and it was found out that force of friction would cause a decrease in kinetic energy and friction force would differentiate according to the kind of surface.

In the control group, the same activities that were shown in Table 2 without robotics technology as they were in the curriculum were implemented in the same period of time as in the experimental group (Figure 3).

Figure 3

Control Group Experimental Activities

Table 2

Control Group Activity Program

Week 1	Introduction of Experimental Activities
Week 2	Implementation of Various Experimental Show Activities
Week 3	Walking Race (Which is the fastest?) *Designing: 10 min., Application-data obtaining: 15 min., Evaluation: 15 min.*
Week 4	Let's Design a Dynamometer (Relationship between Weight and Elongation Amount in Bow) *Designing: 10 min., Application-data obtaining: 10 min., Evaluation: 15 min.*
Week 5	Speed-Mass-Kinetic Energy (Relationships between Speed-Mass-Kinetic Energy) *Designing: 10 min., Application-data obtaining: 15 min., Evaluation: 15 min.*
Week 6	Transformation of Energy (Energy Transformation on Inclined Plane) *Designing: 10 min., Application-data obtaining: 15 min., Evaluation: 20 min.*
Week 7	The decrease in Kinetic Energy (Relationships between Force of Friction-Surface-Energy) *Designing: 10 min., Application-data obtaining: 15 min., Evaluation: 15 min.*
Week 8	Evaluation of Activities

In each group, an integrative laboratory approach was adopted. In a laboratory where an integrative approach is used, students are left alone with the problem. Students organize the experiment, collect and analyze the data, and create new ideas by sharing their results with their friends. In this open-ended approach, the student is active at every stage of the application (Çepni, Ayvacı, 2019b). Also, in this study, the students practiced in cooperative groups during all activities in each group, where the teacher was guiding, and the students were being active. Additionally, *experiment worksheets* which were prepared to use in each activity in each group, were used to evaluate the activities during the process along with the implementation. After activities continued during a total of eight weeks, post-tests were implemented, and data were collected.

Analysis of Data

In this research, data obtained from the implementation were analyzed by using SPSS 17.00 package software. Nonparametric tests were preferred in data analysis since the number of participants in the groups is low. Because the probability of failure in assumptions in parametric tests would increase by the decrease a number of participants (Sümbüloğlu, Sümbüloğlu, 2019).
Accordingly, *Mann Whitney U-Test* was applied for the difference between pre-test points, and *Wilcoxon Signed Ranks Test* was applied for the difference between pre-test and post-test points, and *Mann Whitney U-Test* was applied for the difference between post-test points in the experimental and control group students who participated in the research. The data obtained in the research were evaluated at a 0.05 meaningfulness level. The results of evaluation reached were given in the section of findings and comments.

Answers given to the questions are graded by evaluating in terms of fluency, flexibility and authenticity (Kadayıfçı, 2008). Accordingly, 1 point (fluency point) for each answer produced for the firsts 4 questions, +1 point (flexibility point) for each different application recommended, 2 points for each answer that is given by less than 5%, 1 point (originality point) for an answer that is given by 5%-10% are given. Grading differs in other questions as seen in Table 3. Besides, in this study, the answers given by the students for an objective scoring were examined separately by both the researcher and a faculty member other than the researcher and the consistency rate in scoring was determined using the reliability formula (Reliability = Consensus / Consensus + Disagreement) proposed by Miles & Huberman (1994). As a result of the calculation, the reliability value was found 0.88 and the scoring was accepted as reliable.

Table 3

Grading of the Answers of Scientific Creativity Test (SCT)

	Fluency point	Flexibility point	Authenticity point
Question 1	1 point for each answer	+1 point for each different answer 1. General means of the usage 2. Kinds of glass 3. Physics 4. Chemistry 5. Biology/health/medicine 6. Technology/device	2 points for each answer that is given by less than 5% 1 point for each answer that is given by 5%-10%
Question 2	1 point for each answer	+1 point for each different answer 1. History of the planet 2. Structure of the planet 3. Aliens 4. Utilization 5. Place of living	2 points for each answer that is given by less than 5% 1 point for each answer that is given by 5%-10%
Question 3	1 point for each answer	+1 point for each different answer 1. Aesthetics 2. Security 3. Speed/Energy 4. Functionality 5. Comfort/Convenience	2 points for each answer that is given by less than 5% 1 point for each answer that is given by 5%-10%
Question 4	1 point for each answer	+1 point for each different answer 1. Living beings 2. General life and physics laws 3. Planet and nature 4. Human and his life 5. Social life 6. Transportation, vehicles and inventions	2 points for each answer that is given by less than 5% 1 point for each answer that is given by 5%-10%
Question 5	2 points for each answer that is given by less than 5% 1 point for each answer that is given by 5%-10% 1 point for each answer that is given by more than 10% (a combination of fluency and authenticity)		
Question 6	Maximum 9 points for each method given (3 points for instruments, 3 points for principles and 3 points for procedure) Total 18 points if the answer is given includes two excellent methods.		4 points for methods less than 5%, 2 points for methods between 5%-10%
Question 7	3 points for each different function of the machine		A point between 1-5 depending on a general comprehensive observation

Results

Results Related to the Effect of Robotic Activities on Scientific Creativity

In the first part of the research, findings obtained from *"Scientific Creativity Test"* whose reliability coefficient was calculated as α=0.80 for the study group will be given. Accordingly, first, SCT pre-test points of the experimental and control group students who participated in the research were compared. According to the analysis results shown in Table 4, no meaningful difference at 0.05 meaningfulness level was found statistically between SCT pre-test points of the experimental and control group students. Namely, it can be said that the experimental and control group students who participated in the research were equal before the application in terms of scientific creativity ($U=195.00$; $p>0.05$).

Table 4

Results of Mann Whitney U-Test about the difference between SCT Pre-test Points of the Experimental and Control Group Students

		N	Mean Rank	Sum of Ranks	U	p
SCT Pre-test	Experimental	20	20.75	415.00	195.00	0.89
	Control	20	20.25	405.00		

Results obtained by examining SCT pre-test post-test points of control group students are shown in Table 5. Accordingly, a meaningful difference at 0.05 meaningfulness level was found statistically between SCT pre-test post-test points of the control group students. Namely, it was seen that traditional laboratory activities performed in the scope of the "Force and Motion" unit did not have a meaningful effect on the scientific creativity of the control group students (z=1.21*; p>0.05).

Table 5

Results of Wilcoxon Signed Ranks Test about the difference between SCT Pre-test Post-Test Points of the Control Group Students

Control Group SCT Pre-test Post-test	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	2	1,50	3,00	1,21*	0,22
Positive Ranks	3	4,00	12,00		
Equal	15	-	-		

*Note. * Based on negative ranks*

When the results shown in Table 6 were examined, a meaningful difference at 0.05 meaningfulness level was found statistically between SCT pre-test post-test points of the experimental group students. Namely, it was seen that robotic-assisted laboratory activities performed in the scope of the "Force and Motion" unit had a meaningful effect on scientific creativity of the experimental group students (z=3.92*; p<0.05).

Table 6

Results of Wilcoxon Signed Ranks Test about the difference between SCT Pre-test Post-test Points of the Experimental Group Students

Experimental Group SCT Pre-test Post-test	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	0	0,00	0,00	3,92*	0,00
Positive Ranks	20	10,50	210,00		
Equal	0	-	-		

*Note. * Based on negative ranks*

At this stage of the research final, SCT post-test points of the experimental group students were compared and results were shown in Table 7. Accordingly, analyses done showed that there was a meaningful difference at 0.05 meaningfulness level in favour of the experimental group statistically between the SCT post-test points of the experimental and control group students. Namely, it can be said that the robotic-assisted laboratory activities implemented in the experimental group were more effective compared to the traditional laboratory activities implemented in the control group (U=94.50; p<0.05).

Table 7

Results of Mann Whitney U-Test about the difference between SCT Post-Test Points of the Experimental and Control Group Students

		N	Mean Rank	Sum of Ranks	U	p
SCT Post-test	Experimental	20	28,78	575,60	94,50	0,02
	Control	20	20,70	414,00		

On the other hand, when the answers given to SCT questions at the beginning of the application examined, it is seen that objects like *microscope, telescope, lens, magnifying glass* were given as an example for the possible scientific usages of a piece of glass in the first question (authenticity point is 0 as it was more than 10%). The most authentic answers taken from the experimental group students in the post-test were *beaker* and *glass microscope slide-cover slip* (authenticity point is 1 as it is between 5%-10%).

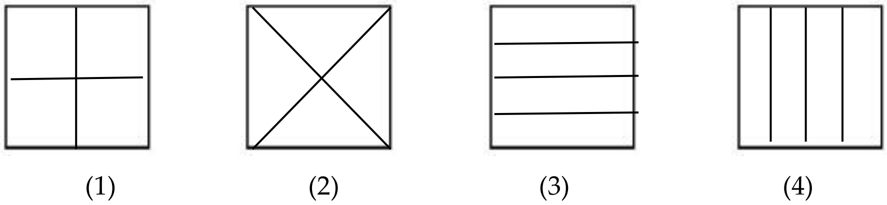
Secondly, it was seen that the students generally had scientific questions to investigate like *whether there existed life, water, oxygen and food on the planet* to the question, "What kind of scientific questions would you have to make research on a planet?" before the application (authenticity point is 0 as it was more than 10%). Originally, some students from the experimental group asked questions such as *"Is there gravity on the planet?", "How the planet moves?", "What would happen if human lived on the planet?", "What sort of life exists on the planet?"* after the implementation (authenticity point is 1 as it is between 5%-10%).

Thirdly, students were asked what corrections they could do to make a bicycle more interesting, practical and nicer, and while answers like, *"I install the engine and make a motorbike, I make it shiny so that it can be visible at night", "I put on headlight in the front for make it easier to go at night"*, most before the application (authenticity point is 0 as it was more than 10%), some authentic answers like, *"I build a system to cover it when I want", "I make it to fly"* were received especially from the experimental group after the application (authenticity point is 1 as it is between 5%-10%).

In the pre-test when the students were asked how the earth could be if there were not gravity in the next question they mostly expressed that *everything would fly in the air* and that *life would get more difficult* (authenticity point is 0 as it was more than 10%); in the post-test, they expressed differently that *life will end* and *everybody will be miserable* (authenticity point is 1 as it is between 5%-10%).
When they were asked, what are the different methods of dividing a square into four equal parts, while the most often made drawings of the students who showed their answers by drawing were the drawings number 1 and 2, which were shown in Figure 4, the drawings number 3 and 4 were original ones which were made less than number 1 and 2.

Figure 4

Drawings of the Students for SCT the 5th Question



(1) (2) (3) (4)

When the students were asked the question *"There are two sorts of napkins. How would you test which one is better?"* (authenticity point is 0 as it was more than 10%); in the SCT pre-test while the students mostly gave such answers like, *"I pour water and wipe it with a napkin, the one absorbing batter is better.", "I try to pull them apart, the one tears earlier are worse."*; they also gave authentic answers like, *"I test whether they are soft or hard, the one softer is better.", "I wipe off the stain on table, the one cleaning better is better."* in the post-test (authenticity point is 1 as it is between 5%-10%).

Finally, when the students were asked to design an apple collecting machine, they drew their designs and described the function of each part. As seen in Figure 5, it is possible that the drawings of the experimental group students were simpler in the beginning, and their drawings after the application were more functional and authentic.

Figure 5

An Example of the Drawings of the Experimental Group Students to SCT the 7th Question a) Pre-test Drawing b) Post-test Drawing

Results Related to the Effect of Robotic Activities on Scientific Attitude

In the second part of the research, findings obtained from *"Scientific Attitude Test"*, whose reliability coefficient was calculated as α=0.82 for the study group were given. Accordingly, first, SAS pre-test points of the experimental and control group students who participated in the research were compared. As seen in Table 8, no meaningful difference at 0.05 meaningfulness level was found statistically between SAS pre-test points of the experimental and control group students. Namely, it can be said that the experimental and control group students who participated in the research were equal before the application in terms of scientific attitude (U=187.00; p>0.05).

Table 8

Results of Mann Whitney U-Test about the difference between SAS Pre-test Points of the Experimental and Control Group Students

		N	Mean Rank	Sum of Ranks	U	p
SAS Pre-test	Experimental	20	19,85	397,00	187,00	0,72
	Control	20	21,15	423,00		

On the other hand, when SAS point averages of the students who participated in the research were examined, it is seen that they had higher attitude points in items like *"Scientific developments attract my attention.", "I want to learn more about scientific subjects (experiments).", "Science enables us to understand natural events better."*; but they had lower attitude points in items such as, *"I like participating in discussions about scientific matters.", "I want to be a scientist in the future."* at the beginning of the application.

SAS pre-test post-test points of the control group students who participated in the research were compared in Table 9. Similarly, no meaningful difference at 0.05 meaningfulness level was found statistically between SAS pre-test post-test points of the control group students. Namely, it can be said in line with the findings obtained that traditional laboratory activities performed in the scope of the "Force and Motion" unit, did not have a meaningful effect on the scientific attitudes of the control group students (z=0.37*; p>0.05).

Table 9

Results of Wilcoxon Signed Ranks Test about the difference between SAS Pre-test Post-Test Points of the Control Group Students

Control Group SAS Pre-test Post-test	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	2	3,00	6,00	0,37*	0,70
Positive Ranks	2	2,00	4,00		
Equal	16	-	-		

Note. * *Based on positive ranks*

Comparison of pre-test post-test points of experimental group students who participated in the research is in Table 10. The data obtained show that there is a meaningful difference at 0.05 meaningfulness level statistically between the SAS pre-test post-test points of the experimental group students. Accordingly, it can be interpreted from the findings obtained that the robotic-assisted laboratory activities performed in the scope of the "Force and Motion" unit, had a more meaningful effect on the scientific attitudes of the experimental group students compared to the students attend in traditional laboratory activities (z=3.43*; p< 0.05).

Table 10

Results of Wilcoxon Signed Ranks Test about the difference between SAS Pre-test Post-test Points of the Experimental Group Students

Experimental Group SAS Pre-test Post-test	N	Mean Rank	Sum of Ranks	z	p
Negative Ranks	0	0,00	0,00	3,43*	0,00
Positive Ranks	15	8,00	120,00		
Equal	5	-	-		

*Note. * Based on negative ranks*

According to the data in Table 11, which SAS post-test points of the experimental and control group students who participated in the research were compared, there was a meaningful difference at 0.05 meaningfulness level in favour of the experimental group statistically between the SAS post-test points of the experimental and control group students (U=122.50; p<0.05).
Findings at this stage can be interpreted as that the robotic-assisted laboratory activities developed the scientific attitudes of the students who participated in the research more compared to traditional laboratory activities.

Table 11

Results of Mann Whitney U-Test about the difference between SAS Post-Test Points of the Experimental and Control Group Students

		N	Mean Rank	Sum of Ranks	U	p
SAS Post-test	Experimental	20	26,38	527,60	122,50	0,04
	Control	20	21,05	421,00		

Furthermore, when SAS point averages of the experimental group students who participated in the research were examined, it is seen that they had higher attitude points in items like *"I like making experiments in the laboratory", "Technology is necessary for our life, "We must follow the scientific way to improve our system of thinking", "Development of the science is the major way for the development of a country", "I use technology since it makes my life easier"* at the end of the application compared to the beginning.

Discussion, Conclusion and Suggestions

In this research, the effect of robotic-assisted experimental activities in the "Force and Motion" unit in the secondary school 7th grade Science and Technology course on the level of scientific creativity and scientific attitude of students was investigated. The research which was in the nature of pre-test post-test with a control group of quasi-experimental design continued for total of eight weeks. The results obtained from this research in line with the research questions are evaluated separately below in terms of scientific creativity and scientific attitudes.

The first research result is intended to the effect of robotics technology on students' scientific creativity. According to the pre-test results done before the application, no meaningful difference was found statistically between SCT pre-test points of the experimental and control group students. Namely, it can be said that the experimental and control group students who participated in the research were equal before the application in terms of scientific creativity. Thus, it is seen that the conditions were equal for all the students who participated in the research before the application. According to the results obtained after the applications, a meaningful difference was found statistically between SCT pre-test post-test points of the experimental group students; and also, between SCT post-test points of the experimental and control group students. Thus, it was found out that robotic-assisted laboratory activities performed within the scope of the “Force and Motion” unit affected the scientific creativity level of the experimental group students positively. Such that it was seen that the experimental group students who gave simpler answers that do not go beyond what is seen to SCT questions before the application, could think more authentic, creative and inquiry-based after the robotic-assisted laboratory activities. As also seen in Figure 6, it can be shown as a reason that in robotic-assisted laboratory activities, the students could make different robot designs aimed at the target by forcing the limits of their imagination and searching for alternative solutions without experiencing negative passive psychology caused by technology. Because using robotics, which encourages learners to construct their robots, introduce new, creative and innovative technologies to learners. So that learners have a mindset to become active technology/science creators rather than passive technological consumers (Eguchi, 2014; cited by Aristawati et al., 2018). As Skluzacek (2017) stated since the robots are created from building blocks, students have an almost infinite array of configurations they can build, inspiring creativity and increasing engagement and there is not one right way to complete a robotic challenge, in this way students can become creative in their robotic program. This situation could be considered as the reason why the robot design process activated creative thinking in our study. Indeed, Piotrowski & Kressly (2009) also concluded that using robotics education kits developed students’ imagination and creativity with different robot design models in their study. In addition, in this research, it has emerged that robots made with legos are also used in science laboratories, providing a very suitable environment for the students to improve their scientific creativity.

Figure 6

Experimental Group Robotic-Assisted Laboratory Applications (RoboLab)

Similarly, the literature review also shows that technology-assisted education with educational robotics kits improves students' creative thinking skills (Avcı, 2017; Baek, Yoon, 2016; Botelho et al., 2012; Chao, 2012; Çavaş et al., 2012; Kırkan, 2018; Nemiro et al., 2017; Siper-Kabadayı, 2019; Sullivan, 2011) and provides a positive contribution to students' curriculum learning by creating a rich and creative environment (McDonald, Howell, 2012). Among these studies, Çavaş et al. (2012) observed that the use of robots in lessons improved the students' scientific creativity performance in their study with students at 6th and 7th grade in the robot club using the Lego Mindstorms robotics education set. On the other hand, Avcı (2017) concluded that Lego Mindstorms robotics projects had a significant effect on the development of teacher candidates' scientific creativity skills in his study conducted with 20 teacher candidates. Differently, Eraslan-Güney (2015) found that robotic activities on renewable energy did not make a significant difference in students' creativity levels in her study conducted with 8th grade students. In this study, it is thought that all the activities carried out are based on two fixed robotic models measuring and are not effective in creativity development as they do not allow enough flexibility to students in robot design. Indeed, Kırkan (2018) supports this situation with the result that students think more flexibly and develop original products when designing robots made with their ideas instead of robot models designing by giving catalogs in this way. In our study, it could be said that this was an element activated and supported creative thinking, since an open-ended robotic design process that did not proceed on fixed models was carried out.

The other research results obtained are related to the effect of robotics technology on the scientific attitudes of students. According to the pre-test results done before the application, since no statistically significant difference was found between SAS pre-test points of the experimental and control group students; it was seen that the experimental and control group participating in the research at the beginning of the application were equivalent in terms of scientific attitudes. According to the results obtained after the applications, a meaningful difference was found statistically between SAS pre-test post-test points of the experimental group students; and also, between SAS post-test points of the experimental and control group students. Thus, it was determined that robotic-assisted laboratory activities performed within the scope of the "Force and Motion" unit affected the scientific attitude level of the experimental group students positively. The reason for this is that students can use their robots actively while testing their hypothesis in science experiments in which they follow the scientific research method. When looked at from this point of view, it can be stated that the results we obtained in regard to the potential of robotics technology for scientific attitude development are in parallel with the results of many kind of research that exist in the literature (Nugent et al., 2010; Terry et al., 2011; Welch, Huffman, 2011). However, this research has been focused on the fact that the scientific attitudes of the students have improved with the use of robotics in science experiments. In this context, if both the results obtained in this study and the other results in the literature are considered, it is very clear that robotics technology supports and develops scientific attitudes.

Another result reached in the research was that the traditional laboratory activities performed in the scope of the "Force and Motion" unit, did not have a meaningful effect on scientific creativity and the scientific attitudes of the control group students. It can be said that this result is not surprising given the fact that traditional laboratory applications remote from technology gives a limited opportunity for students to the hypothesis, test hypotheses and discuss experimental errors. When considered that traditional kits used in today's laboratories that are out of technology may limit students, prevent them from conducting experiments with an investigative and quizzical approach, and cause too much time loss (Koç, Büyük, 2015), this result was expected. In this study, the same laboratory approach was used in both groups, the same scientific method was followed, but the traditional materials used in the control group did not provide a design process that would allow students more than one combination as in the experimental group. Besides, the students in the control group made measurement mistakes and lost time because they could not draw graphics simultaneously on the program as in the experimental group, so they were able to spare less time for scientific discussion. All these situations are thought to be effective in the result obtained. Indeed, researches have similarly shown that traditional laboratory activities are insufficient to improve the creativity of students (Feyzioğlu et al., 2011a; Russell, Weaver, 2011). In this context, science laboratories inevitably need technological applications that will enable to emerge and develop scientific creativity and scientific attitudes of students and give them a multi-dimensional perspective.
From the point of view of all the results obtained in this study, it is obvious that the level of scientific creativity and scientific attitude of students which had an important place in teaching Science and Technology could be developed more by using robot technology actively in science laboratories. Therefore, it is recommended that robotic-assisted science laboratory activities should also implemented extensively in different classes, units or subjects to provide a more quality science teaching that is supportive and improving for scientific creativity and scientific attitudes of students. At this point, the Ministry of National Education (MNE) supported projects can be initiated to provide robotics sets. Thus, within the framework of the 2023 Education Vision announced by the MNE in

2018, it is thought that an important step will be taken in line with the main goal of enabling innovative applications in education. An example of such a projects was implemented by the United Arab Emirates Ministry of Education in 2013. In line with the vision of adopting technology-based sustainable education, the Ministry of Education initiated the 'Robot Bag' project to equip students with scientific skills, develop their innovative thinking and creativity, and provided robotic materials to many public schools within the scope of the project.

Consequently, when robotics is considered a promising technology works to be done in this field becomes more important day by day. At this point, researches like the effect of robotics applications in the education of Science and Technology on the success of students and their attitudes towards course, their contribution to the skills of finding practical solutions to daily life problems, their potential to guide students to Science and Technology related professions are considered as significant researches to advise other researchers.

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Appendix

Appendix 1

Questions of Scientific Creativity Test

Question 1	Unusual usages	Write the possible scientific purpose usages of a piece of glass. *For example, a test tube can be made.*
Question 2	Finding out the problem	What kind of scientific questions would you have to make research if you had a spaceship to travel in space and went to a planet? *For example, is there any alive beings living on the planet?*
Question 3	Product development	Think of possible corrections that can make a normal bicycle more interesting, practical and nicer. *For example, tires can be applied shiner thus making it visible at night.*
Question 4	Scientific imagination	Imagine there is no gravity and describe how the earth can be. *For example, human beings could fly.*
Question 5	Problem-solving	Use possible methods to divide a square into four equal parts. Draw your answer.
Question 6	Science experiment	There are two kinds of napkins. How can you test to find out which is better? Please write possible instruments, methods and principles which you can use with their simple procedure.
Question 7	Product designing	Please design an apple collecting machine. Draw its picture, name your machine and indicate the function of each part of it.

Appendix 2

Scientific Attitude Scale (SAS)

	ITEMS	Agree	Partly don't agree	Don't agree
1.	Scientific developments attract my attention.			
2.	I want to learn more about scientific subjects (experiments).			
3.	I want to be a scientist in the future.			
4.	I want to learn how the historical development of science was.			
5.	I wonder life stories and inventions of scientists in the past.			
6.	I wonder about the result of an experiment that is been conducting.			
7.	I wonder about the structure and mechanism of the universe.			
8.	I wonder how scientific projects are done.			
9.	I enjoy following scientific developments.			
10.	I enjoy making observations about events in nature.			
11.	I like making experiments in laboratory.			
12.	I like watching scientific documentaries and movies.			
13.	I like participating in discussions about scientific issues.			
14.	Technology is necessary for our life.			
15.	Science enables us to understand natural events better.			
16.	We must follow the scientific way to improve our system of thinking.			
17.	The development of science is the major way for the development of a country.			
18.	I use technology since it makes my life easier.			
19.	I can easily use technological tools relevant to their purpose.			