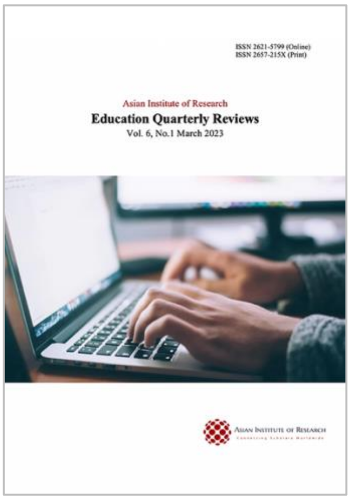

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The Effect of Lego Robotics Coding on Primary School Students' Academic Achievement and Attitudes of Science

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Abstract
The current research aims to examine the effects of LEGO robotics coding on primary school students' academic achievement and attitudes toward science courses. A pretest-posttest control group design was used in the study and the participants joined the study randomly divided into control and experimental groups. While the control group was trained with the traditional method, the experimental group was trained via the constructivist method. To determine the effects of two different teaching methods on the student's success and attitudes, the science lesson attitude scale was applied in a pre-test and post-test form. The study group consists of 33 students who were randomly selected. Through the study, we concluded that LEGO robotics coding provides more meaningful and effective learning on primary school student's academic achievement and attitudes when compared with the control group.

Keywords: Lego Robotics, Academic Achievement, Attitude to Science

1. Introduction

Current rapidly changing science and technology applications closely affect the developments in various fields. This change revealed the need for innovation in the field of education as well, and the use of education-oriented robotic kits has become more widespread. Böylece robotik kitlerin bilgisayar aracılığıyla kodlanmasının tüm öğrenciler için ilgi çekici bir uygulama olması ve aynı zamanda onların problem çözme, yaratıcı düşünme ve bilişimsel düşünme becerilerini geliştirmesi beklenmektedir (Yolcu & Demirer, 2017).

The Science Lesson can be defined as the ways of acquiring knowledge that constantly develops and renews itself based on the regular knowledge that people have acquired about themselves and their natural environment (Morgil, 1990:21). Individuals who learn science gain the ability to understand and assimilate the events occurring around their environment more easily. Science education is also thought to be a necessary and important function to keep up with the rapid developments and innovations in the field of science and technology (Hançer et al., 2003).

Thanks to science education, likely to be defined as "the education of the events that arouse curiosity, surprise, and the events going on around the individual" (Gürdal, 1992), we can notice and define the events around our environments in a better way. It is crucial for a person to have a good science education to realize that the events in his/her environment have something to do with science and to understand that he/she is a whole with science (MEB, 2016). For this reason, science education is considered to be taught in the most appropriate way to suit the interests and needs of people. When science is taught in an easy and understandable way as in nature, it provides individuals with the knowledge and also the ability to find solutions to the problems encountered in the course of life. Likewise, teaching by doing, and experiencing is argued to be important and more meaningful for the students (Langdon et al., 2011). While teaching science education, students should be asked to ponder the problems and solutions that they come across in daily life. Students should also be encouraged to cooperate and work in groups. The teacher should also be able to teach according to the current developments and be updated on changes in the field of education. The method of memorizing directly without questioning the information is insufficient for the education of the current age. For this reason, the students should be raised questioning and researching the information, assimilating and making sense of it, and having the ability to solve all kinds of problems. The new approaches are also of great importance for raising these individuals (Hamurcu et al., 2001).

Despite the technology applications in education cannot solve all the problems experienced, it is thought to be important for increasing the level of education. Thus, The Ministry of National Education of Turkey made changes in the education programs in 2004 and the process of integrating technology with education was started. Through this process, the traditional approach was abandoned, and the constructivist approach was preferred, technology has been more extensively used for all activities, and students have also been the focus of these activities (Canbulat & Yüce, 2018). With Turkey's adoption of the technology-based economy model, the strategic importance of STEM (Science, Technology, Engineering, Mathematics) has emerged in terms of international competitiveness.

STEM education, described as the result of the cooperation and performance of various fields working in an integrated manner, is also considered as the work of these fields together in relation to any kind of problem. Students who carry out activities that are adopted this approach utter that working with the principles of different fields in problem-solving is similar to collaborating with real-life professionals. Therefore, it is argued that STEM education conveys interdisciplinary cooperation in practice to students by modeling (Aslan-Tutak, et al., 2017). STEM education, through the holistic approach based on interdisciplinary relations and interaction, fulfills the functions of raising individuals who are open to research, design, problem-solving, cooperation, and communication in education that deals with the mentioned fields not separately, on contrary, together. Fusing the fields of science, STEM education aims to harmonize the contents with each other, technology and mathematics, and to provide students with the ability to solve problems and make connections between the contents they learn and real life (Buyruk & Korkmaz, 2016). Thanks to STEM education, particularly through the interdisciplinary integration approach, curiosity, and questioning skills that are already present in people but have become atrophied over time are revived, and an educational approach that tries to develop expertise to transform the knowledge is adopted via different disciplines (Wang et al., 2011; Altunel, 2018).

In STEM education, subjects are presented to students in connection with real life. Hence, by combining disciplines, a complementary approach is created, and a meaningful link related to learning for students is served. The student's concentration on complex problems are though to have a positive effect on their success. Design and engineering-oriented activities not only contribute to the learning of other disciplines but also likely support the development of students' problem-solving, creativity and communication skills (Wang et al., 2011; Yılmaz, et al., 2017).

STEM education focuses on four fundemantal disciplines. However, engineering and technology fields are more prominent. While all of these disciplines can be combined, an approach based on combining only two is also accepted (Yenilmez & Balbağ, 2016). Through STEM education, responsibility is instilled in students, on the other hand, the awareness of that making mistakes is inevitable and natural is also emphasized. While STEM supports students' creative and innovative ideas, it also orients the children to an education integrated with science, engineering and mathematics technology, starting from an early age. The understanding of STEM, focusing on creativity, cooperation, communication and entrepreneurship, is based on principles that raise collaborative, entrepreneurial and creative individuals (Keçeci et al., 2017). One of the crucial aspects of STEM is considered to be robotic coding. With the current development of robotic coding programs, it is observed that more research has been made on the coding of robotic kits. Such programs are thought to make coding easier for younger students to learn, owing to their visual environment and drag-and-drop code block structures (Aytekin et al., 2018).

It is stated that studies carried out with robotic applications have become widespread in recent years and Lego-based robotic environments are widely used (Costelha & Neves, 2018).

Çakır and Güven (2019) reports that students actively find the opportunity to embody science concepts with robotic coding activities and carry out such activities in an enjoyable way can be more efficient for improving students' attitudes toward science lessons. Silva (2008) states that robotic activities increase students' motivation and are beneficial for their personal development. Likewise, the study of Çakır and Güven (2019) revealed that robotic coding activities are effective in concretizing science concepts and increasing their attitudes. Heafner (2004) states that the use of technology in lessons enables students to focus on learning and increases their learning motivation. Additionally, robotic coding is also argued to increase students' programming skills and motivation and offers many opportunities for their development (Behrens et al., 2010; Mayerova, 2012).

The current research aims to examine the effects of LEGO robotics coding on primary school students' academic achievement levels and attitudes towards the science course. Accordingly, answers to the following questions were sought.

1. Does conducting the science course with LEGO robotic coding increase the academic success of primary school students in a statistically significant way?

2. Does conducting science lessons with LEGO robotic coding increase primary school students' attitudes toward science lessons in a statistically significant way?

2. Method

2.1. Research Pattern

In the study, a pretest-posttest control group design was used. The participant students were randomly chosen and divided into control and experimental groups. While the control group was trained with the traditional method, the experimental group was trained with the constructivist method. The research has two dependent variables, academic achievement and attitude toward science. The teaching methods applied throughout the research process form the independent variables. The experimental group was taught via LEGO robotic teaching technique which was based on a student-centered method, on the other hand, the control group was taught via a lecture presentation which was based on a teacher-centered method.

To determine the effects of two different teaching methods on the success of the students and their attitudes towards the science lesson, an academic achievement test consisting of the knowledge and comprehension level of the cognitive domain and a science lesson attitude scale were applied to all the participant students via a pre-test and post-test form. The subject of "Force and Motion" was taught to the experimental group in the innovation class at the school, while the subject of "Force and Motion" was taught to the control group by direct expression and presentation. Pre-test and post-test applications were fulfilled by using SCAAT (science course academic achievement test) and SCAS (science course attitude scale).

2.2. Working group

The study group was randomly formed by 17 participant students and the control group by 16 participants.

2.3. Data Collection Tools

An Achievement Test (SCAAT) and a Science Attitude Test (SCAS) were used to collect the data in the research.

2.4. SCAAT (Science Course Academic Achievement Test)

While SCAAT was being developed, the curricula of the 4th-grade primary school on "force and motion" were examined, the achievements that students are already supposed to know were determined, and a 40-question-item test was formed. 4 classroom teachers and 3 science teachers were interviewed on the items, and accordingly, 7 question items were dismissed from the test by consensus as they were not to be suitable for the level of the students. After analysis of the remaining 33 questions, another 4 question items were also eliminated and the total number of question items was reduced to 29 due to their low validity. The KR-20 value of the achievement test was observed as 0.88 which was a valid level.

2.5. SCAS (Science Course Attitude Scale)

SCAS, developed by Edge and Balcı (2012), consists of 12 items, a 5-point Likert-type scale. Scale options are “Strongly Agree”, “Agree”, “Moderately Agree”, “Disagree”, and “Strongly Disagree”. The reliability of the scale is 0.83, which is regarded as valid for reliability.

2.6. Analysis of Data

Item analysis was performed for the achievement test, and the question items to be removed and the reliability coefficient of the test were calculated. The comparison of the scores of the two classes was analyzed with the independent group t-test, while the comparison of the first and second measurements was analyzed with the dependent groups' t-test.

2.4. Experimental Study

The subject of "Force and Motion" in the science lesson was taught by using coding and lego robotics for the experimental group. The student was first informed that they would learn the topics about "force and motion" such as swinging, turning, changing direction, acceleration, and deceleration, and the lesson was started with "scratch" in coding. Scratch 3.0, a programming tool created for children over eight (8) years old, consists of three parts. In the first part, the character was created, in the second part, the commands were written, and those commands were activated in the last part. The motion types were learned with the codes given to the videos and animations created. Then, m-block coding studies were carried out with the students. M-block is a programming software designed for the purposes of the STEM education system. With mblock, the subject of "force and motion" was studied by giving complex textual commands (mblock3,mblock5).

Code.org is based on object-oriented coding and provides drag-and-drop command execution. In the scenes of "ANGRY BIRD AND ZOMBI PLANTS", the types of force movements were also examined. After each successful task, they moved on to the next task and completed the tasks they had coded. The subject is also reinforced with LEGO WEDO. Lego wedo is a set that enables children to develop in the fields of science and provides engineering and coding experience with the created projects. The smart brick consists of motor, motion, and training sensors. A group of sumo wrestler robots were made by the experimental group with the LEGO WEDO set.

Apart from this, their movements were observed by making air, land, and sea vehicles. Lifting force was learned with a set of simple machines. Additionally, creativity and engineering skills have been developed with building sets. While sumo wrestling is made with Mbot robots, pushing and pulling forces were studied once again. It was taught to stop when they come across mbot robots when they are at the same speed, and when they are one after another, they accelerate with the effect of pushing. With robots called "Botto", the movement type of changing direction on the map has also been reinforced. The rotational movement was observed with the aircraft and helicopter propellers. The swinging motion was studied with simple machines and pendulums. During all these studies, the experimental group learned by having fun, as they already took an active role in the process.

3. Findings

3.1. Testing Equivalence of the Groups

The Independent groups t-test was applied to the equivalence test of the experimental and control groups according to the pre-test results. The results of the related test are seen in Table 1 below.

Table 1: Testing the Groups Equivalence

		n	Average	ss	t	p
Science Attitude - Factor 1	Experiment Group	16	4,13	0,97	-0,919	0,365
	Control Group	17	4,36	0,43		
Science Attitude - Factor 2	Experiment Group	16	2,85	0,42	2,401	0,023*
	Control Group	17	2,53	0,35		
Science Attitude - Factor 3	Experiment Group	16	2,48	0,96	0,969	0,340
	Control Group	17	2,18	0,83		
Achademic achievement (Pre-Test)	Experiment Group	16	10,00	2,58	1,332	0,192
	Control Group	17	8,88	2,23		

*p<0,05

The results of the t-test on the comparison of the Attitudes and Achievement Scores for experimental and control groups are seen in the table above. Accordingly, the Science Attitude factor 2 score differs ($p<0.05$) and the scores in the experimental group were higher than the average scores. However, there are no statistically significant differences in the other two sub-dimensions, which measures students' attitudes toward science lesson ($p>0.05$).

3.2. Comparison of Pre-Test and Post-Test Results Within Groups

The table indicating the change in the pre-test and post-test measurements of the students in the experimental group is shown below.

Table 2: Comparison of Pre-Test and Post-Test Results of the Students in the Experimental Group

	Average	ss	t	p
Academic Achievement Test (Pre-Test)	10,00	2,582	-42,959	0,01*
Academic Achievement Test (Post-test)	25,63	1,408		
Science Attitude - Factor 1 (Pre-Test)	4,12	0,96	-1,852	0,08
Science Attitude - Factor 1 (Post-Test)	4,67	0,50		
Science Attitude - Factor 2 (Pre-Test)	2,85	0,42	-12,586	0,01*

Science Attitude - Factor 2 (Post-Test)	4,50	0,47		
Science Attitude - Factor 3 (Pre-Test)	2,47	0,95	-8,225	0,01*
Science Attitude - Factor 3 (Post-Test)	4,83	0,66		

*p<0,05

The results of the t-test are seen in Table 4 above. According to the results, there is a statistically significant difference between the pre-test scores and the post-test scores of the students in class 4A from the academic achievement test (p<0.05). Accordingly, achievement test scores increased by 156% from 10.00 to 25.63. When the scores of the attitude scale were examined, no statistically significant difference was observed in the context of the first factor of the scale (p>0.05). But a statistically significant difference was observed in the context of the second and third factors (p<0.05).

The table indicating the change in the pre-test and post-test measurements of the students in the control group is shown below.

Table 3: The Pre-Test and Post-Test Results in the Control Group

	Average	ss	t	p
Academic Achievement Test (Pre-Test)	8,88	2,23	-18,998	0,01*
Academic Achievement Test (Post-Test)	16,94	3,69		
Science Attitude - Factor 1 (Pre-Test)	4,36	0,43	3,80	0,01*
Science Attitude - Factor 1 (Post-Test)	3,03	1,49		
Science Attitude - Factor 2 (Pre-Test)	2,52	0,35	-1,36	0,19
Science Attitude - Factor 2 (Post-Test)	2,84	0,98		
Science Attitude - Factor 3 (Pre-Test)	2,10	0,80	-3,19	0,06*
Science Attitude - Factor 3 (Post-Test)	3,04	1,11		

*p<0,05

The results of the t-test of the control group students are shown in table 6. According to the results, there is a statistically significant difference between the achievement test pretest and post-test scores in the control group (p<0.05). Accordingly, achievement test scores increased by 91% from 8.88 to 16.94. In addition, when the attitude of the students in the control group was examined, a statistically significant difference was observed in terms of the first and third factors (p<0.05), While no statistically significant difference was observed in the second factor (p>0.05).

3.3. Comparison of Post-Test Results

The table indicating the results of the independent groups t-test of the experimental group and the control group is shown below.

Table 4: Comparison of Post-Test Results

		n	Average	ss	t	p
Science Attitude - Factor 1	Experiment Group	16	4,67	0,50	4,15	0,01
	Control Group	17	3,03	1,49		

Science Attitude - Factor 2	Experiment Group	16	4,50	0,47	6,12	0,01
	Control Group	17	2,84	0,97		
Science Attitude - Factor 3	Experiment Group	16	4,83	0,66	4,98	0,01
	Control Group	17	3,15	1,17		
Academic Achievement Test (Pre-Test)	Experiment Group	16	25,63	1,48	8,80	0,01
	Control Group	17	16,94	3,69		

*p<0,05

According to the results in Table 6, the attitudes and academic achievements of the experimental group toward science were higher than the control group ($p<0.05$). In other words, the post-test results of the group taught with the LEGO coding method were higher than the group with the traditional method on the basis of all three scales.

3. Discussion and Conclusion

The current study basically focused on the effect of coding with LEGO robotics on primary school student's academic achievement and attitudes toward science lessons. The results in the literature relevant to science courses reveal that coding and robotic kits have become more efficient in science teaching. The students taking an active role in the process of robotics and coding have problem-solving skills in an educational and creative learning environment. Through robotics and coding, individuals are provided with many skills such as mathematical thinking, problem-solving, and creative thinking skills (Fidan & Yalçın, 2012).

The pretest applied to 4th grade primary school students' revealed that there is no significant difference between the experimental and control groups. Thus, we argue that the attitudes of both groups towards science are equivalent to each other. However, post-test results of the scientific attitude scale are likely to increase positive attitudes toward science when the Lego robotics were applied to the experimental group. Additionally, in the control group, to which the narrative method was applied, we observed that there was no significant difference in favor of the group in the pretest and posttest of SCAS (Science Course Attitude Scale).

Studies on robotic applications have become widespread in recent years and Lego-based robotic environments are widely used (Costelha & Neves, 2018). In one of these studies, Silva (2008) states that robotic activities increase students' motivation and are beneficial for their personal development. In another study, Çakır and Güven (2019) state that robotic coding activities are effective in concretizing science concepts and improving students' attitudes. Heafner (2004) states that the use of technology in lessons enables students to focus on learning and increases their learning motivation. Researchers, Behrens et al., 2009 and Mayerova 2012, state that robotic coding improves students' programming skills and motivation and offers many opportunities for their personal development. Likewise, our findings in the current study are consistent with the findings of the researchers (Çakır and Güven, 2019; Heafner, 2004; Behrens et al., 2010; Mayerova 2012) who state that robotic-assisted science experiments and robotic coding applications improve students' attitudes towards science lessons. Based on these results, we argue that robotic coding practices affect students' attitudes positively.

In a study conducted by Özer (2019) with 87 students to determine the effect of using robots in coding education on achievement, motivation and problem solving skills of 5th and 6th grade students. During the same period, they learned to code without using a robot. The research indicated a statistically significant differences between the experimental and the pre-test and post-test scores in both groups. When the post-test scores of the groups were compared in our study, we observed that there was a significant increase in favor of the experimental group. The academic achievement pretests of the experimental group taught with Lego robotics and the control group students taught by the narrative teaching methods indicated similarity with each other. In other words, the achievements of these two groups on the subject of "force and movement" in the science curriculum revealed similar results. However, in the posttest, there was a positive difference in favor of the experimental group. Accordingly, the academic success of the experimental group was higher than the academic success of the control group as a result of the experimental procedure.

Based on our findings within the current study, it can be argued that Lego robotics applications should be more emphasized within science teaching, considering that such a model improves the students' attitudes towards the science course and their academic achievements are positively affected.

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