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Research Paper

The Effect of Robotic Programming on Coding Attitude and Computational Thinking Skills toward Self-Efficacy Perception

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ABSTRACT

The purpose of this study is to determine the effect of coding instruction performed with the Lego Mindstorms EV3 robotic set on students' attitudes towards coding and their perceptions of computational thinking skills self-efficacy. Single group experimental research design was used in the research. The study group of the research consisted of 30 sixth grade students who studied at a secondary school in the 2019-2020 academic year. These students selected the Information Technologies and Software lesson within the context of Support and Training Course. The research was carried out with robotic coding activities for 7 weeks, two lessons per week. In order to collect the research data, the Attitude Scale for Coding Education and the The Self-Efficacy Perception Scale for Computational Thinking Skill were applied as pretest and posttest. According to the findings of the research, after teaching programming with robotic coding activities, there was a significant increase in students' positive attitudes towards coding and a decrease in their negative attitudes, but this decrease was not found to be statistically significant. In addition, it was found that there was a statistically significant change between pre-post and post-study in all sub-dimensions of students' computing thinking skills self-efficacy perceptions.

INTRODUCTION

In today's world, as a general education policy, it is seen that individuals should be raised with computational thinking skills starting from preschool, which is a necessity of this age, regardless of the fields they will tend to afterwards. When it comes to computational thinking, it is seen that there are different uses that meet this concept in the literature. In this context, it is possible to say that actually “computational thinking” is meant with different expressions such as "computer-like thinking, information-technology thinking, calculative thinking" (Demir & Seferoğlu, 20017). It can be said that computational thinking is defined as a kind of problem-solving skill and is one of the competence areas in today's world (Üzümcü & Bay, 2018). Computational thinking can be expressed as knowing the basic concepts in computer science and using them in problem solving (Curzon, Peckham, Taylor, Settle, & Roberts, 2009).

On the other hand, computer programming is thought to be important in acquiring computational thinking skills. It is stated that computer programming plays an important role in acquiring problem solving skills as well as reasoning (Kalelioğlu & Gülbahar, 2014). From this point of view, in today's sense of education, programming education is tried to be given to all individuals in order to enable them to gain problem solving and computational thinking skills. However, it is stated that this is difficult and the success of the students is low in programming teaching carried out at different ages and education levels (Garner, 2003; Robins, Rountree, & Rountree, 2003). In the literature it is suggested that the reasons such as programming environments being text-based and requiring code writing are effective in the emergence of this situation (Gültekin, 2006; Mannila, Peltomäki, & Salakoski, 2006). In recent years, increasingly, block-based visual programming tools with different infrastructures have been developed. Generally, these environments are designed to appeal to individuals of all ages who have no programming experience. Thus, the necessity of learning programming with text-based programming environments is tried to be eliminated. As a matter of fact, in the literature, it can be seen that the effects of block-based programming tools on programming teaching are discussed in various aspects (Alrubaye, 2017; Dinçer, 2018; Hu, Chen, & Su, 2020; Lee, 2019; Seraj, 2020; Shim, Kwon, & Lee, 2017; Şimşek, 2018; Vatansever, 2018; Yıldırım, 2017).

When the subject of coding is examined, it is seen that one of the variables discussed is attitude. Attitude refers to the tendency to respond positively or negatively to any object. It has long been assumed that attitudes have affective, behavioral, and cognitive components. These interconnected components affect how a person reacts to an object (Reich-Stiebert, Eyssel, & Hohnemann, 2018). The attitude towards any situation or object may change as a result of a single experience or change gradually as a result of a series of experiences (Arslan, 2006). In the literature, it is stated that learners' negative attitudes towards programming negatively affect programming teaching. In this context, it can be thought that the use of robotic sets in coding teaching may affect learners' attitudes towards coding in different ways.

The widespread use of robotic sets that can be coded with visual programming tools has revealed the idea that robotic sets can be easily used to support students' learning in the field of Science, Technology, Mathematics and Engineering (STEM). STEM is the expression of creating a product by using science, technology, engineering, and mathematics together (Bybee, 2010). Robotic sets contain features that enable students to use the knowledge and experience they have gained from different disciplines and to create their own designs. Studies in the literature show that robotic-based activities have positive effects on STEM and contribute to students' learning and increase their motivation (Benitti, 2012; Bodle, 2019; Lee, Liew, Bin Mohd Anas Khan, & Narawi, 2020; Liu, Lin, Feng, & Hou, 2013; Mosley, Ardito, & Scollins, 2016; Pinasa & Srisook, 2019; Suárez-Gómez & Pérez-Holguín, 2020). This has brought out a field known as educational robotics. The robotics field can be considered as a process of creating a learning product by putting research, inquiry and critical thinking skills into practice (Aksu, 2019). In many countries, robotics-based learning approach through simple robotics training sets has been implemented since the end of the 1990s. In Turkey, since the same years, robotics coding trainings have been carried out as pilot scheme or via robotics competitions as well (Koç-Senol, 2012). Today in the market, robotic sets such as “Arduino, mBot, Lego Mindstorms, Lego We Do 2.0, Dash & Dot, Makey Makey, Vex IQ, Vex EDR” designed in different ways and used for coding teaching are available (Aksu, 2019). In these sets, there are motors of different sizes, sensors with different features, programmable circuit boards for designed robots to perform the required tasks. For programming robots, visual programming environments that can be used by every individual of different ages and levels such as "Scratch, mBlock, Lego mindstorms EV3 programming tool, We Do 2.0 programming tool, Wonder, Blockly, MODKIT VEX programming tool, ROBOTC programming tool, VEX coding studio programming tool" have been developed.

One of the robotic sets widely used for teaching coding is "Lego Mindstroms EV3". The Lego Mindstorms EV3 set, produced by the Lego company, is a technology that allows students to work individually and as a group and to design robots with the robot building guides presented in the Lego website (See Figure 1). In the Lego Mindstorms EV3 set; there are lego pieces, various sensors, motors and a programmable smart brick. Programmable bricks of robots created with the help of a guide or originally can be connected to PC or mobile devices wired or wirelessly (Lego, 2019).

Figure 1. Robot Examples Designed with Lego Mindstorms EV3 Set

Robots created with the help of a guide or in an original way can be coded with the Lego Mindstorms EV3 programming tool installed on PC or mobile devices. Lego Mindstorms EV3 programming tool can be supplied from Lego website as PC or mobile version (See Figure 2). In addition, with an application called Commander, the designed robots can remotely be controlled by mobile devices without necessity of any programming (Lego, 2019).

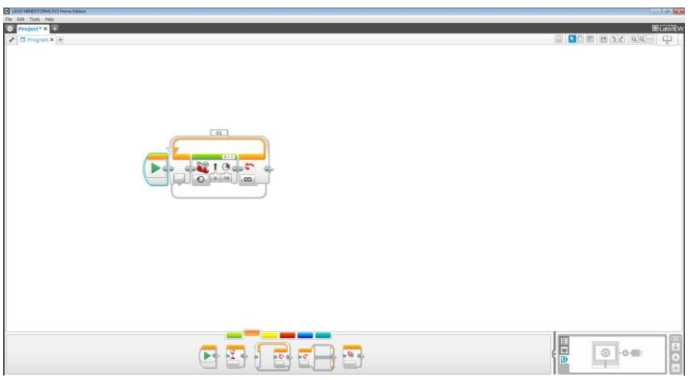

Figure 2. Screenshot of Lego Mindstorms EV3 Programming Tool

When the literature on robotics is examined, it is understood that different robotic sets such as “Lego Mindstroms EV3” are used in programming teaching (Usengül & Bahçeci, 2020; Aksu, 2019; Avcı & Şahin, 2019; Noh & Lee, 2019; Muñoz-Repiso & González, 2019; Durak, Yilmaz, & Yilmaz, 2019; Özer, 2019; Taylor & Baek, 2018; Çukurbaşı & Kıyıcı, 2017; Kasalak, 2017; Korkmaz, 2016; Chaudhary, Agrawal, & Sureka, 2016; Koç-Şenol, 2012). These studies were carried out with participants of different ages and levels. In these studies, the effects of robotic sets in different dimensions were examined.

Usengül and Bahçeci (2020) examined the effect of LEGO WeDo 2.0 robotic education on students' academic achievement, attitude and computational thinking skills towards science. The participants of the study were generated from 36 Grade 5 students in a school in Turkey. The method of study was determined as an experimental method with pretest and posttest control groups. Eleven weeks of robotic coding activities were carried out with the participants of the study. As a result of the research, it was reported that the academic achievement and computational thinking skills of the students in the experimental group differed significantly from those in the control group. Taylor and Baek (2018) investigated the effect of gender and group roles on students' robotic performance, computational thinking skills, and motivation for programming learning. In the study, coding project activities were carried out in groups with the Lego Mindstroms EV3 robotic set. The results of the research revealed that while working on robotic projects, students' roles within the group positively affect their robotic performance and computational thinking skills. In the study, it was also stated that there was a difference in the motivation of students towards computer programming according to group roles. In their research, Çukurbaş and Kıyıcı (2017) studied the effect of algorithm teaching with the use of Lego Mindstroms EV3 robotic set on the academic achievement and motivation of high school students. At the end of the research, it was concluded that students' motivation and academic achievement increased significantly as a result of the practices with the robot set. In his study with university students, Korkmaz (2016) compared the use of traditional method in teaching C ++ programming language with Lego Mindstorms EV3 robotic activities. As a result of the research, it was determined that the teaching supported by robotic activities had a positive contribution to the academic success of the students compared to the teaching with the traditional method. Chaudhary, Agrawal, and Sureka (2016) carried out a study in STEM field with primary school students using the Lego Mindstorms EV3 robotic education set. During the research process, students were trained on how to design robots and how to program the created robots. As a result, it was observed that the education carried out with the robot set was effective for the students in acquiring STEM skills and they became successful in a regional tournament they joined.

Noh and Lee (2019) designed a robot programming course for elementary school students. They investigated the effectiveness of this design by applying it in real classrooms. The designed robot programming lesson was implemented with the participation of 155 5th and 6th grade students. The implementation lasted eleven weeks. The findings of the study showed that teaching programming using robots significantly improves numerical thinking and creativity. However, it was observed that the computational thinking skill did not develop significantly in the study group, which showed high scores at the beginning. Muñoz-Repiso and González (2019) studied the effect of educational robotic activities on kindergarten students' computational thinking and programming skills. The research was designed with a quasi-experimental method, using the experimental and control groups, with pretest and posttest measures. The sample of the study was composed of 131 students (3-6 years old), all of whom were attending a kindergarten in Spain. As a result of the research, it was revealed that the computational thinking skills of the students in the experimental group increased in a statistically significant way compared to the control group students. Durak, Yilmaz and Yilmaz (2019) researched middle school students' experience in problem solving skills in numerical thinking, programming self-efficacy and reflective thinking skills and in the programming education process related to robotic activities. For this purpose, a 10-week study was carried out with 55 students from 6th and 7th grades in secondary school. Mixed method was used in the study. As a result, it was revealed that students' numerical thinking skills, programming self-efficacy and reflective thinking towards problem solving were at a moderate level. Özer (2019) examined the effect of robotic sets used in programming teaching on middle school students' achievement levels, motivation and problem solving skills. As a result of the research, it was determined that the robotic sets used in programming teaching had a positive effect both on students' level of achievement and problem solving skills. On the other hand, Aksu (2019) reached the conclusion that the problem solving skills and scientific creativity of pre-service teachers developed at the end of the activities in which robotic sets were used. Kasalak (2017) investigated the effects of robotic coding activities on students' self-efficacy perceptions and learning experiences of coding. At the end of this study, it was stated that robotic coding activities had positive thoughts about students' self-efficacy perceptions and learning experiences. Koç-Şenol (2012) examined the effect of robotic activities on students' scientific process skills and motivation in his study. In the study, it was found that the students had positive opinions about robotics, and the use of these sets increased students' scientific process skills and motivation.

Generally, in the studies, it can be said that robotic sets were used in both coding teaching and STEM trainings, and their effects on different dimensions such as motivation, attitude, computational thinking skills, problem solving skills were examined, and as a result, robotic sets made positive contributions to these dimensions.

Purpose and Importance of the Research

Computational thinking skill is expressed as the combination of creativity, algorithmic thinking, critical thinking, problem solving and collaborative working skills (ISTE, 2015). Computational thinking enables individuals to automate problem solutions and to broaden the limits of thinking. When students learn and assimilate the concepts and principles of computer science, they can get prepared better for changing daily life and business life with technology (Gülbahar, Kert, & Kalelioğlu, 2019). International Society for Technology in Education (ISTE) and Computer Science Teachers Association (CSTA) expressed the computational thinking skill as a problem solving process that generally includes the following features:

- Formulating problems in order to solve by using computers and some other tools,
- Editing and analysing data logically,
- Re-presenting data in abstract structure as models or simulations
- Making solutions autonomous by using algorithmic
- Identifying, analyzing and applying possible solutions to provide the most effective and efficient combination of steps and resources
- Transferring and generalizing the problem solving process for the solution of different problems (ISTE & CSTA, 2011).

Looking at ISTE and CSTA's computational thinking skills definition, it can be seen that these skills contain elements similar to computer programming skills. Based on this, it can be said that programming teaching can be used in the acquisition of computational thinking skills. At this point, now in Turkey,too, as an education policy, it can be seen that programming teaching gradually gets more important with the aim of improving students’ computational thinking and problem solving skills.

Self-efficacy is expressed as the judgment, belief about oneself that a person can achieve a successful result by organizing all the activities required to show a certain performance (Bandura, 1997). Studies have shown that people who have a high self-efficacy perception about any situation make more effort to accomplish the task subject to this situation, are more patient in the face of negativity and are more persistent and determined to succeed. In this context, it appears that the perception of self-efficacy is an important element of education (Aşkar & Umay, 2001). From this point of view, it is clear that determining the self-efficacy perception level created by the robotic programming activities carried out especially for younger individuals to gain computational thinking skills will be useful for the future processes and will provide important feedback to the practitioners.

Due to the fact that, since computer programming, or coding skill, is seen as a 21st century skill, visual programming courses have been added to the primary and secondary school curricula of many countries around the world, especially in recent years (Baz, 2018). In Turkey, starting from elementary school, problem solving and programming subjects can be seen in Information Technology and Software course curriculum (MEB, 2017). In addition, coding teaching was included as a national education policy in the 2023 Vision Document (MEB, 2019) published by the Ministry of National Education (MEB). In the Vision Document, it is stated that in-service training will be offered to classroom teachers in order to teach algorithmic thinking skills in non-computer environments starting from primary school. Thus, the work to be done to train students as producers with coding training was specified as a target (MEB, 2019). As a reflection of this general goal, programming teaching, which is tried to be enriched with robotic coding activities, has been started with a limited number of courses in middle and high schools. It is thought that robotic sets, which are widely used in programming teaching, aim to visualize programming and develop a positive attitude towards coding. However, it can be seen that it is difficult for every school or student to reach robotic programming sets due to the high costs. Based on this fact, it is thought that knowing the effect of robotic sets on students' attitudes towards coding will help institutions and teachers to make the right decisions, and also provide useful feedback to their designers to design the robotic sets according to their purpose.

In summary, especially in recent years, programming teaching has started to find place in education policies on a world-wide scale. In this direction, various innovations occur in the robotic sets used in teaching day by day. In general, it is thought that robotic sets embody programming teaching. However, due to the cost of robotic sets, many students cannot provide these sets. Therefore, robotic coding studies can generally be carried out as group works with a limited number of robotic sets in a small number of schools. It can be seen that it is important to examine this issue in different dimensions and levels. As a result, it is thought that researching the effect of Lego mindstorms EV3 robotic set, which is frequently used at secondary school level in programming teaching, on computational thinking skill self-efficacy perception and attitude towards coding will provide important feedback to decision-makers and contribute to the literature.

Purpose of the Research

The general aim of this study is to investigate the effects of robotic sets used in programming teaching on students' attitudes towards coding and self-efficacy perceptions of computational thinking skills. In line with this general purpose, the following questions were sought in the study:

1. What is the effect of programming teaching performed with the Lego mindstorms EV3 robotic set on students' attitudes towards coding?
2. What is the effect of programming teaching performed with the Lego mindstorms EV3 robotic set on students' computational thinking skills self-efficacy perceptions?

METHOD

In this study, in order to reveal the effect of robotic sets used in programming teaching on middle school students' attitudes towards coding and their self-efficacy perceptions of computational thinking skills, a pretest posttest single-group (without a control group) experimental research design was used. In this design, the effect of the operation is tested with the study performed on a single group. The measurements of the participants related to the dependent variable are obtained from the same participants and with the same measurement tools as pretest before the application and posttest after the application (Gay & Airasian, 2000; Cohen & Manion, 1997; Fraenkel & Wallen, 1996). There is no randomness or matching in this pattern. For this design, single factor in-group or repeated measures design definitions are also used (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, & Demirel, 2012). The single group pretest-posttest experimental design is considered as one of the weakest designs among experimental designs. However, as in this study, the preference of a single group experimental design in studies in which a newly developed teaching module is applied is due to the nature of the study (Creswell, 2012).

The independent variable of the study is the use of robotic set in programming teaching and the dependent variables are computational thinking skill, self-efficacy perception and attitude towards coding. The quantitative data of dependent variables in the study were collected through scales applied after obtaining the necessary permissions. The schematic representation of the experimental model used in the study is given in Table 1.

Table 1. Research Model Used in the Study

Research Group	Initial Measurement	Process (Operations)	Final Measurement
Experimental Group	ASFCE-1 SPSFIPT-1	7 Weeks Robotic Programming Activities	ASFCE-2 SPSFIPT-2

ASFCE-1: Attitude Scale for Coding Education (Pretest)
SPSFIPT-1: Self-Efficacy Perception Scale for Information-Processing Thinking (Pretest)
ASFCE -2: Attitude Scale for Coding Education (Posttest)
SPSFIPT 2: Self-Efficacy Perception Scale for Information-Processing Thinking (Posttest)

Ethical principles were followed in all stages of the study. First of all, the necessary research permission was obtained from the institution where the study will be carried out. In addition, the students and their parents who make up the study group of the research were informed, and it was stated that they could not participate in this study if they wanted. As a result, the necessary study approval was obtained from all the students and their parents in the study group.

Study Group

The study group of the research consists of 30 (15 females, 15 males) sixth grade students studying at a secondary school in Tokat in 2019-2020 academic year and took the Information Technologies and Software (ITS) course within the scope of the Support and Training Course (STC) (See Table 2).

Table 2. Distribution of Study Group in Terms of Gender

Gender	f	%
Female	15	50
Male	15	50
Total	30	100,0

There are several main reasons for the limited study sample. First of all, the study was carried out within the scope of the course opened for students willing to learn programming after school hours. Since the robotic sets to be used during the research are expensive, only 3 robotic sets could be obtained. Teaching activities had to be carried out with group work by using these limited number of robotic sets. In addition, in order to ensure efficient teaching and student motivation, as few students as possible were included in the study groups.

The study was implemented in the ITS course of STC for 7 weeks, two hours a week, with a total of 30 students in December 2019-January 2020. Within the scope of the study, programming teaching was carried out in groups with robotic programming activities. During the study, all lessons were taught by one of the researchers. The reason why the research group was chosen from the mentioned institution is that the researcher who carried out the study was a teacher there. Within the scope of the research, "Lego Minstroms EV3" from Robotic sets was used for programming teaching.

Data Collection

As data collection tool; the "Attitude Scale towards Coding Education (ASTCE)", for pretest-posttest, developed by Karaman and Büyükalan-Filiz (2019) and the "Computational Thinking Skill Self-Efficacy Perception Scale for Secondary School Students (CTSSEPS)" developed by Gülbahar, Kert and Kalelioğlu (2019) were used.

The Attitude Scale towards Coding Education is arranged in a 5-point Likert type, consists of two dimensions (General Positive Attitude towards Coding Education, General Negative Attitude Towards Coding Education) and 41 items. There are no reverse-coded items in the scale. Likert options of the scale were determined as "strongly disagree, disagree, partly agree / partly disagree, agree, strongly agree". These options were scored as "Strongly Disagree-1", "Disagree-2", "Partly Agree-Partly Disagree-3", "Agree-4", "Strongly Agree-5". In order to determine the validity and reliability of the scale, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were carried out by the researchers who developed the scale. As a result of EFA, 41 items, the variance explained for 2-factor structure was determined as 47,892%. It was observed that the factor loads of the scale items were between 0.530-0.737. The ratio of the chi-square value obtained from the scale as a result of CFA (1938,878 / 778 = 2,492) has a value below 2.5. The goodness of fit index revealed as a result of the Confirmatory Factor Analysis (CFA) showed that the model was congruent. In the light of the data obtained as a result of the analysis, it has been interpreted that the scale is valid and reliable (Karaman & Büyükalan Filiz, 2019).

Self-Efficacy Scale for Computational Thinking Skill for Secondary School Students consists of 3-point Likert-type, five-dimensional (Algorithm Design Competence, Problem Solving Competence, Data Processing Competence, Basic Programming

Competence, Self-Confidence Competence) and 36 items. There is no reverse item in the scale. Likert options of the scale are "yes, partially and no". The options are scored as "Yes-1", "Partially-2", and "No-3". In order to determine the validity and reliability of the scale, the researchers who developed the scale carried out statistical studies of EFA, CFA and item analysis, and independent groups t-test. EFA results showed that the scale consists of 39 items and a five-factor structure. As a result of CFA, 3 items were removed from the scale and the 36-item scale was finalized. It was determined that the corrected item-total score correlation values of the factors were between 0.632 and 0.386, and the Cronbach Alpha coefficients varied between 0.762 and 0.930. As a result of the t-test performed, it was determined that all the differences between the item averages of the upper 27% and the lower 27% groups were statistically significant. In the light of the obtained analysis results, it was stated that the scale has a good level of item discrimination, internal consistency and high reliability (Gülbahar et al., 2019).

Implementation

This study was carried out in the first semester of the 2019-2020 academic year, with thirty 6th grade students studying at a secondary school in Tokat. The topics to be covered during the research study were determined based on the behavioral objectives of "Problem Solving and Programming Unit" included in Information Technologies and Software Curricum of the Middle School and Imam Hatip Secondary School Information Technologies and Software Course (5th and 6th grades) (MEB, 2017). Within the framework of these behavioral objectives, robotic coding topics were created as a result of the literature review and were presented to the opinion of a university lecturer and two Information Technologies teachers before starting the application. Experts who examined the relationships between the objectives of robotic coding activities and the objectives of programming subject in the Information Technologies and Software course curriculum suggested various corrections in order to fully reflect the objectives of variable, operator, linear logic, decision structure, loop structure, which are programming concepts in robotic coding activities. In this framework, the objectives of robotic coding activities were finalized in line with the opinions and suggestions of the experts (See Table 3).

Table 3. Robotic Coding Activities Behavioral Objectives Table

Week	Course period	Topics	Achievements
1st Week	2	EV3 Brick (Programmable Smart Brick) Use, EV3 Interface	• Knows the names of EV3 Set pieces and functions. • Knows the functions of the buttons on EV3Brick. • Opens and uses interface menus in EV3 Brick.
2nd Week	2	EV3 Sensors, EV3 Motors, EV3 Input/ Output Connections	• Knows properties of EV3 Touch Sensor • Knows properties of EV3 Infrared Sensor. • Knows properties of EV3Colour Sensor. • Knows properties of EV3 Ultrasonic Sensor. • Knows properties of EV3 Medium Motor. • Knows properties of EV3 Large Motor. • Makes connections of EV3 sensors and motors with EV3 Brick.
3rd Week	2	Making humanoid robot with manual collected from e-book and web resources	• Joints lego pieces properly according to application guide • Connects EV3 Sensors and motors with EV3 Brick according to application guide.
4th Week	2	EV3 Software Use, EV3 Introduction to Programming	• Downloads and installs EV3 Programmer App (IOS/Android) to tablets. • Downloads and installs EV3 Programming Software (PC/Mac) to PC or MAC computers. • Installs Robot Commander App to smart phones.

5th Week	2	Touch Sensor and Programming Application via Large Motor	• Knows the commands of touch sensor and uses the commands appropriate to its purpose. • Knows the commands of infrared sensor and uses the commands appropriate to its purpose.
6th Week	2	Infrared Sensor, Touch Sensor, Programming Application via Large Motor and Medium Motor	• Knows the commands of infrared sensor and uses the commands appropriate to its purpose • Knows the commands of middle motor and uses the commands appropriate to its purpose. • Knows the commands of large motor and uses the commands appropriate to its purpose.
7th Week	2	Touch Sensor, Color Sensor, Infrared Sensor, Large Motor Programming Application	• Knows the commands of touch sensor and uses the commands appropriate to its purpose. • Knows the commands of color sensor and uses the commands appropriate to its purpose. • Knows the commands of infrared sensor and uses the commands appropriate to its purpose. • Knows the commands of infrared sensor and uses the commands appropriate to its purpose.

Later on, lesson activities were planned in accordance with the determined objectives. At this stage, resources and e-books accessed on the internet were used. The activities prepared were designed as suitable for the basic programming behavioral objectives mentioned before and allowing students to do it as a team. The designed robotic coding activities were presented based on the opinion of a university lecturer and two Information Technologies teachers. Experts evaluated the appropriateness of robotic coding activities to the robotic coding objectives and student readiness level determined in line with the programming objectives in Information Technologies and Software course curriculum and then suggested some changes. In line with these opinions and suggestions from the experts, the activities were finalized.

In accordance with the objectives such as "Creates programs containing decision structure, debugs them by testing." and "Creates programs containing loop structure, debugs them by testing." included in the Information Technologies and Software course (5th and 6th grades) (MEB, 2017) curriculum, an example of robotic coding teaching activity designed according to "Knows the commands of the Color Sensor and uses the commands appropriate to its purpose", which is one of the robotic coding teaching objectives realized in this study and "Knows the commands of middle motor and uses the commands appropriate to its purpose." objective, used in our study, an example is presented in Figure 3.

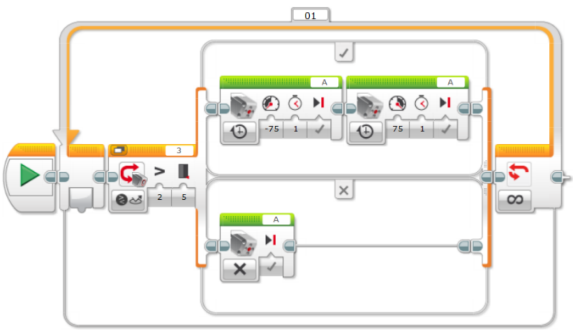

Figure 3. Sample Activity Created via Lego Mindstorms EV3 Programming Tool

An activity was designed in accordance with Information Technologies and Software course (5th and 6th grades) curriculum (MEB, 2017) objectives such as "Creates programs that contain decision structure, debugs errors by testing." and "Creates programs that contain the loop structure, debugs them by testing." In addition, the robotic coding teaching activity was designed in accordance with the acquisitions "Knows the commands of the color sensor and uses the appropriate commands", "Knows the commands of the infrared sensor and uses the commands appropriate to its purpose." and "Knows the commands of the big engine and uses the commands appropriate to its purpose." An example for this sample activity is given in Figure 4.

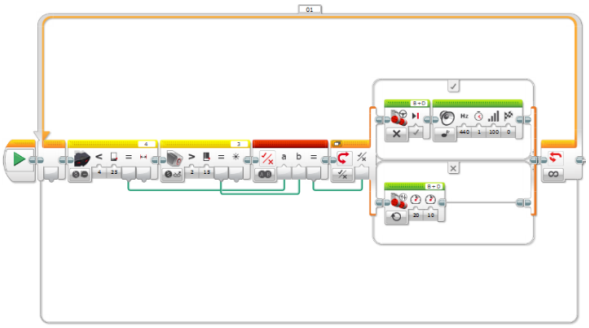

Figure 4. Sample Activity Created via Lego Mindstorms EV3 Programming Tool

Before starting the application, the participant students were informed about the robotic coding activities to be carried out by one of the researchers. 3 Lego Mindstorms EV3 sets previously available in the institution were used to carry out robotic coding activities. Robotic coding teaching was carried out in two different classes where males and females were separated, and on two different days, 2 course periods per week and as parallel to each other. Both classes were divided into 3 working groups within themselves. In the formation of the study groups, attention should be paid to the heterogeneity of students in terms of ability, achievement, gender and socio-economic level (Gömleksiz, 1993; Miller, 1989). In this context, working groups were tried to be formed by bringing together individuals at different academic levels. In determining the academic levels of the participants, the previous academic exam scores of the students in the information technology and software course were taken into account. As a result, it was tried to be made sure that the study groups were heterogeneous within themselves in terms of academic success and that their levels were close to each other among the groups.

Robotic coding activity was carried out for one week and two periods with the study groups before the actual application. Common problems in group works are disagreements among group members, non-performance of group memmbers in-group tasks, and collaboration causing conflict (Mello, 1993; Sümbül, 1995). During the pilot scheme, the students who had problems in getting along with each other for different reasons were tried to be picked out. In addition, the groups in which intra-group interactions were less frequent during the activities compared to the other groups were determined at this stage. In the light of these data, some minor changes were made in the study groups, taking into account the previously mentioned academic performance criteria, and the study groups were finalized before the actual implementation. Before starting the actual planned application, scales, as data collection tools, were applied to the participants as a pretest. Later, robotic coding teaching was carried out for 7 weeks with the activities created within the framework of the determined objectives (See Figure 5). At the end of robotic coding instruction, scales were applied to the participants as a posttest. Thus, the application phase of the research was completed.

Figure 5. Robotic Coding Teaching Group Activities

ANALYSIS OF DATA

During the data collection stages of the research, necessary guidance and explanations were made by the researcher in order for the participants to fill in the measurement tools completely and accurately. In this context, it was observed that all of the 30 students participating in the study coded the measurement tools properly. Measurement tools were coded from 1 to 30 and all the quantitative data collected were loaded to the computer and made ready for analysis.

Before analyzing the pretest and posttest scores of the attitude towards coding scale and information-processing thinking self-efficacy scale obtained from the participants of the study, it was tested whether the data met the necessary conditions for parametric tests. Then the statistical analysis of the data was carried out. SPSS package program was used for these operations. In the statistical evaluation of the study, paired samples t-test was used. In all analyses, the significance value was accepted as .05.

FINDINGS and DISCUSSION

In this section, the findings obtained as a result of the statistical analysis of the data collected to find answers to the sub-problems of the research and their interpretation are included.

Comparison of Pretest and Posttest Scores of the Attitude Scale towards Coding Education

The first research question of this study was determined as"What is the effect of robotic sets used in programming teaching on students' attitudes towards coding?". In order to find an answer to this question, the attitude scale scores towards coding education applied to the study group before and after the robotic programming teaching activities were compared. In this context, first, the compatibility of continuous variables with parametric tests was tested. Descriptive statistics such as arithmetic mean, skewness and kurtosis coefficient were evaluated in order to determine whether the scale scores provided the normal distribution assumption. In this context, normality tests and graphics were examined. In addition, the Shapiro-Wilk test results were evaluated considering the group size (n <50) (Shapiro & Wilk, 1965). When the Shapiro-Wilk normality test results were examined, it was determined that the significance value of the pretest and posttest scores was greater than .05. According to these results, it was concluded that paired samples t-test can be performed for the scores obtained from the attitude scale towards coding education (See Table 4).

Table 4. Normality Test for Attitude Scale Towards Coding Education

Attitude Scale Towards Coding Education	Statistics	sd	p
Pretest	0.94	30	0.08
Posttest	0.93	30	0.06

The t-test analysis results for paired amples made in order to understand whether there is a significant difference between the pretest and posttest scores of the attitude scale towards coding are presented in Table 5.

Table 5. Comparison of Attitude Scale Towards Coding Education Pretest-Posttest Scores

ASTCE Sub-dimensions	Tests	n	$\bar{X}$	Ss	sd	t	p
General Positive Attitude Towards Coding	Pretest	30	105.73	19.24	29	2.87	.008
	Posttest	30	119.93	18.45			
General Negative Attitude Towards Coding	Pretest	30	25.63	7.50	29	1.72	.095
	Posttest	30	22.60	9.95			

In the study in which the effect of robotic programming on attitude towards coding was investigated, the average of pretest general positive attitude scale scores of the study group was 105.73 and the standard deviation was 19.24. As a result of the measurement carried out after the courses in which robotic coding was taught, the average of the posttest attitude scale scores was 119.93, and the standard deviation was 18.45. It has been revealed that the pretest and posttest positive attitude scale scores show a statistically significant difference ($t(29) = 2.87$; $p < .05$). According to the results of the analysis, it can be said that there is a statistically significant change in the positive attitude of the study group, in which robotic coding instruction was used throughout the study, towards coding between before and after the implementation.

In this study, in which the effect of robotic programming on students' attitudes towards coding was investigated, the mean scores of the study group's pretest general negative attitude scale were found to be 25.63, and the standard deviation 7.50. As a result of the measurement performed after the lessons in which robotic coding was taught, the average of the posttest negative attitude scale score was 22.60, and the standard deviation was 9.95. It was revealed that the pretest and posttest negative attitude scale scores did not show a statistically significant difference ($t(29) = 1.72$; $p > .05$). According to the results of the analysis, it can be said that; there was no statistically significant change in the study group's, in which robotic coding instruction was used throughout the study, negative attitude towards coding before and after the implementation.

Within the scope of the research, the effect of programming instruction, in which robotic coding activities were performed, on students' attitudes towards coding was tried to be determined. In this context, the mean scores obtained from the attitude towards coding scale applied before and after the research were compared. As a result, at the end of the programming teaching performed with robotic coding activities, the results were obtained that there was a significant increase in students' positive attitudes towards coding, and a decrease in their negative attitudes, but this decrease was not statistically significant. In the literature, it can be seen that similar studies have been conducted in different age groups and similar results to this study have been reached in general (Arslan & Tanel, 2021; Kasalak, 2017; Korkmaz, 2016; Kök, 2019; Jun, 2018; Gunbatar & Karalar, 2018; Merkouris, Chorianopoulos and Kameas, 2017; Martín-Ramos et al., 2017; Shim, Kwonand Lee, 2017).

Arslan & Tanel (2021) examined the effects of Arduino applications on students' attitudes in the programming course. Research findings showed that Arduino applications used in programming education had a positive effect on students' attitudes and this is supported by interview findings. Accordingly, almost all of the students described this app as catchy, interesting, exciting and intriguing. In another study similar to this research, Kök (2019) examined the students' experiences of robotic coding with group work. As a result of the robotic coding activities carried out within the scope of this study, the students' finding the process interesting and their opinions stating that these activities will contribute positively to their other lessons can be interpreted as they developed a positive attitude towards coding in general. Apart from these studies, the findings of two different studies conducted with different robotic sets are noteworthy. The first of these, Jun (2018), researched the effect of software education using robots on primary school students' learning motivation and attitude towards programming. As a result of the research, it was revealed that the motivation of the students to learn programming increased significantly. In addition, it was determined that the attitude towards robot-based software education was statistically significantly improved as "good, useful, interesting, easy, friendly, active, special, understandable, easy, simple". In another study, Gunbatar & Karalar (2018) studied the effect of mBlock programming instruction on students' self-efficacy perceptions and attitudes towards programming. The research was carried out on secondary school students. The results of the study revealed that programming with mBlock significantly increased students' self-efficacy perceptions and attitudes towards programming.

In the literature, in other studies conducted in different contexts with the participation of different age groups, the effect of robotic coding education on attitude towards coding / computer programming has been revealed. In their study, Merkouris, Chorianopoulos, and Kameas (2017) investigated the benefit of using robots and wearable computers for learning coding compared to desktop computer programming. At the end of the study, they stated that the students were more interested in learning programming with robotics instead of desktop computers and that their attitudes towards coding were higher in this sense. Martín-Ramos et al. (2017) investigated the effect of robotic coding performed with Arduino with peer coaching on students' attitudes towards programming, and found that students were satisfied with the robotic coding activities performed throughout the study and that their positive attitude towards coding increased in general. Shim, Kwon, and Lee (2017), in their study for primary school students, investigated the effect of robot programming using a visual programming tool in programming teaching. At the end of the study, they concluded that there was no significant change in students' negative attitudes towards programming, but their positive attitudes increased and their understanding of programming concepts improved. Kasalak (2017) investigated the effect of middle school students' robotic coding activities on their self-efficacy perceptions of block-based programming and student experiences for robotic coding. As a result of his study, it was stated that students developed positive attitudes towards coding activities, and in this context, students were more excited about learning coding, demanded to continue the activities, had fun in the activities and found the activities interesting.

Contrary to the research findings above, there are also studies in which different results are presented in the literature on this subject. Korkmaz (2016) studied the effect of Lego Mindstorms EV3-based programming instruction compared to traditional method on students' attitudes towards learning programming, self-efficacy beliefs and academic achievement. As a result of the research, it was found that Lego Mindstorms EV3 based programming teaching had a significant effect on the academic achievement of students in terms of C ++ programming language compared to the traditional method. When the attitudes of students towards learning programming were examined, it was stated that although the average of the students' attitude scores in the group in which Mindstorms EV3-based programming was taught was higher than that of traditional teaching, it was not found to be a significant difference. This research finding may be important in terms of showing that there may be some other uncontrollable variables that can affect attitude. From this point of view, in order for the use of robotics in programming teaching can have the expected effect on attitude towards coding,it suggests that the teaching method and technique to be used may be important.

Comparison of Pretest-Posttest Scores of the Self-Efficacy Scale Towards Computational Thinking Skill

The second research question of the study was determined as "What is the effect of robotic sets used in programming teaching on students' computational thinking skills self-efficacy perceptions?". In order to find an answer to this question, the computational thinking skill self-efficacy scale scores applied to the study group before and after robotic programming teaching activities were compared. In this context, first, the compatibility of continuous variables with parametric tests was tested. Descriptive statistics such as arithmetic mean, skewness and kurtosis coefficient were evaluated in order to determine whether the scale scores provided the normal distribution assumption. In this direction, normality tests and graphics were examined. In addition, the Shapiro-Wilk test results were evaluated considering the group size (n <50) (Shapiro & Wilk, 1965). When the Shapiro-Wilk normality test results were examined, it was determined that the significance value of the pretest and posttest scores was greater than .05. According to these results, it was concluded that paired samples t-test could be performed for the scores obtained from the attitude scale towards coding education (See Table 6).

Table 6. Normality Test for Computational Thinking Skill Self Efficacy Perception

Computational Thinking Skill Self Efficacy Perception	**Statistics**	**sd**	**p**
Pretest	0.96	30	0.51
Posttest	0.94	30	0.13

The t-test analysis results for paired samples made in order to understand whether there is a significant difference between the Computational Thinking Skill Self-Efficacy Scale pretest-posttest scores are presented in Table 7.

Table 7. Comparison of Computational Thinking Skill Self Efficacy Perception Scale Scores

CTSSEP Sub-dimensions	Tests	n	$\bar{X}$	Ss	sd	t	p
Algorithm Designing Competence	Pretest	30	16.13	4.60	29	4.53	.000
	Posttest	30	21.30	4.20			
Problem Solving Competence	Pretest	30	21.96	3.55	29	5.74	.000
	Posttest	30	25.00	2.88			
Data Processing Competence	Pretest	30	13.57	4.03	29	2.94	.006
	Posttest	30	16.40	3.59			
Basic Programming Competence	Pretest	30	7.77	2.24	29	4.94	.000
	Posttest	30	11.50	2.82			
Self-confidence Competence	Pretest	30	10.20	2.37	29	3.45	.002
	Posttest	30	12.13	2.50			
Total	Pretest	30	69.63	12.98	29	5.92	.000
	Posttest	30	86.33	12.16			

In this study, in which the effect of robotic coding on the perception of computational thinking skills self-efficacy was investigated, it was observed that there was an increase in the posttest scores of the students in the study group in the sub-dimensions of the CTSSEP scale. These increases mean a statistically significant difference in all sub-dimensions as ($t (29) = 4.53$, $p <.05$) in the Algorithm Designing Competence sub-dimension, ($t (29) = 5.74$, $p <.05$) in Problem Solving Competence, ($t (29) = 2.94$, $p <.05$) in Data Processing Competence, ($t (29) = 4.94$, $p <.05$) in Basic Programming Competence, ($t (29) = 3.45$, $p <.05$) in Self-Confidence Competence.

The average pretest total scores of the computational thinking skill self-efficacy scale were found to be 69.63, and the standard deviation 12.98. As a result of the measurement performed after the lessons in which robotic coding instruction was given, the average of the posttest self-efficacy scale scores was 86.33, and the standard deviation was 12.16. In this context, it was seen that the pretest and posttest self-efficacy perception scale scores showed a statistically significant difference ($t (29) = 5.92$; $p <.05$). According to the results of analysis, it can be said that a statistically significant change occurred in the computational thinking skill self-efficacy perceptions of the study group in which robotic coding instruction was used throughout the study, in terms of pre and post study.

Throughout this study, the effect of programming teaching carried out with robotic coding activities on students' self-efficacy perceptions of computational thinking skills was searched. The mean scores obtained from the computational thinking skill self-efficacy perception scale applied before and after the study were compared. As a result, it was determined that there was a significant increase in the computational thinking skills self-efficacy perceptions of the students at the end of the programming teaching in which robotic coding activities were performed. When the literature is examined, it can be said that the results obtained are substantially similar to the results of this study. Although it shows similarities, it can be seen that a number of different results have emerged (Yilmaz Ince & Koc, 2021; Kert, Erkoç & Yeni, 2020; Usengül & Bahçeci, 2020; Özer, 2019; Akbıyık, 2019; Çınar, 2019; Chalmers, 2018; Kırkan, 2018; Atmatzidou & Demetriadis, 2016).

The study conducted by Yilmaz-Ince & Koc (2021) is very close to each other, especially in terms of the research method used. Yilmaz-Ince & Koc (2021) investigated the effect of robotic programming education on computational thinking skills. The research methodology is based on a set of pretest-posttest models in a quasi-experimental design. The results of the research showed that there was a significant increase in the algorithmic and critical thinking factors of robotic programming, while there was no significant change in creativity, collaboration and problem solving factors. When the research results are examined, it can be seen that robotic coding does not have a significant effect on some dimensions of computational thinking skill. From this point of view, it can be concluded that high self-efficacy perception of computational thinking skill does not directly increase computational thinking skill. On the other hand, results that support the findings of our study have been reached in many other studies (Kert, Erkoç & Yeni, 2020; Usengül & Bahçeci, 2020; Atmatzidou & Demetriadis, 2016; Chalmers, 2018; Kırkan, 2018). Kert, Erkoç & Yeni (2020) compared the pedagogical effects of robotics and block-based programming perspectives on secondary school students. The students in the experimental group of the study worked with Lego Mindstorms EV3 sets, and the students in the control group worked with the block-based programming environment (Scratch). Research results showed that educational robotics improved middle school students' academic achievement and computational thinking competency perceptions more effectively than block-based programming environments. Usengül & Bahçeci, in their pretest-posttest control group experimental studies, where they examined the effect of robotic education on the computational thinking skills of students with LEGO WeDo 2.0 of 2020, concluded that the computational-thinking skills of the students in the experimental group differed significantly from those in the control group. Atmatzidou and Demetriadis (2016), in their study investigating the effect of educational robotic activities on students' computational thinking skills, concluded that robotic coding activities, regardless of age and gender, resulted in a positive increase in students' computational thinking skills. Chalmers (2018) examined the effect of robotic coding on students' computational thinking skills. In the study, it was found that robotic coding activities were effective in introducing computational thinking skills to students and helped students improve their knowledge. Kırkan (2018), in his study, tried to determine the views of gifted students in project-based robotics education processes with creative thinking, reflective thinking and problem solving skills and robot development processes. From the data obtained at the end of the research, it was determined that project-based robotics education contributed to the creative thinking, reflective thinking and problem solving skills of gifted students. In addition, it was concluded that the students developed positive attitudes towards robotic based product development.

In the literature, it can be seen that problem solving skill, which is one of the sub-dimensions of computational thinking skill and self-efficacy perception, is frequently emphasized. In this sense, it has been determined that the effect of robotic coding on problem solving skills has been discussed in different studies. The results of these studies support our research findings (Özer, 2019; Akbıyık, 2019). Özer (2019) tried to determine the effect of using robots in coding education on the achievement, motivation and problem solving skills of middle school students. In the application phase of the study, programming teaching was carried out using the block-based visual programming tool in the control group and using robotic activities in addition to the visual programming tool in the experimental group. At the end of the study, it was determined that while there was no change in the problem solving skills of the students in the control group compared to the pre-study, a significant increase occurred in the problem solving skills of the students in the experimental group compared to the pre-study. It was also stated at the end of the study that a significant difference occured in favor of the experimental group in the problem solving skills scores of the groups. Akbıyık (2019) studied the effect of programming teaching carried out with arduino microcontroller applications on students' self-efficacy toward programming and on problem solving skills. Within the scope of the research, 11 weeks of teaching programming was carried out with the students. As a result of the research, it was stated that there was a significant increase in students' self-efficacy perceptions and problem solving skills for programming compared to pre-study results. Contrary to the results of these studies, there are studies reporting different findings (Çınar, 2019). In Çınar's (2019) study, the effects of object-oriented and robot programming on success, abstraction, problem solving and motivation were investigated. At the end of the study, it was seen that there was no statistically significant difference in problem solving scores within or between groups. The fact that the effect of robotic coding on problem solving skill, which is an important sub-dimension of computational thinking skill, has revealed different results in researches suggests that there may be different uncontrollable variables in this regard.

In summary, it can be seen that robotic coding has generally a close positive effect on computational thinking skill and computational thinking skill self-efficacy perception. In addition, in the light of the findings in our research and related literature studies, it can be thought that the positive effect on the perception level can be highly reflected in the skill.

CONCLUSIONS and RECOMMENDATIONS

In this study, the effect of robotic coding instruction using the Lego Mindstorms EV3 set on students' attitudes towards coding and self-efficacy perceptions of computational thinking skills was studied. As a result of the research, it was concluded that there was a positive change both in students' attitudes towards coding and their self-efficacy perceptions towards computational thinking skills, and this was statistically significant.

It is seen that the results of this study are in parallel with the results obtained in the related literature. In this context, it can be said that the Lego Mindstorms EV3 set used throughout this research has a positive effect on students' attitudes and self-efficacy perceptions like other robotic sets used in coding teaching.

In the light of this experience and results obtained within the scope of this study, the following suggestions are presented for researchers who want to do research using robotic coding in programming teaching in the future, and for the teachers who plan to teach programming with robotic coding, and for the decision makers responsible for education:

- This research was carried out with a limited number of robotic sets and a limited number of students. It is thought that it would be beneficial to expand the scope of similar research questions and re-study them with participants from different education levels.
- It is believed that while teaching coding with robotic sets, using different teaching methods and comparing them with each other to present the results will be important in terms of both contributing to the literature and offering alternatives to practitioners.
- It can be said that comparing different robotic sets with each other and stating the results will help the practitioners in making predictions about the results of the teaching they are planning of doing.
- Based on the results that robotic coding makes programming concrete and interesting for students and has a positive contribution to the attitude towards coding in general, it will be important to popularize robotic sets in coding teaching at all ages and levels.
- Considering that robotic coding has a positive effect on young individuals' acquisition of computational thinking skill, which is accepted as a 21st century competence in today's world, it is thought that it will be important to add robotic coding activities to teaching programs and to support schools in terms of infrastructure. In this sense, it is also thought that it will be beneficial for decision makers to take into account of the findings of the literature and thus, develop their education policies accordingly.

Ethics and Consent: Ethical approval was not sought for this study because as is known, there was no ethical approval requirement for research before 2020. The study started in December 2019 and research data were collected in this process. Informed Consent: Verbal informed consent was obtained from legally authorized representatives before the study. Verbal informed consent was obtained from legally authorized representatives before the study. In this context, the students and their parents who constituted the study group were informed before the study and it was stated that they could not participate in this study if they wanted. As a result, the necessary study approval was obtained from all the students and their parents who made up the study group.

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