Examining the Interface of Lego Mindstorms Ev3 Robot Programming

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Article Info	Abstract
  Review Article	Today, the value of training of programming is increasing gradually, and this education is now given at elementary school level. Parallel to this, a wide variety of programming tools have been produced. As those who have just started to take traditional programming education and especially those who are in their early childhood years find this type of programming difficult, block programming languages have been developed. Learners who have just started to learn block programming can adapt themselves more easily to learning programming. With the spread of education on programming, block programming has developed, and a number of languages and materials have been developed for programming robots with blocks. One of the most popular of them is the Lego Mindstorms EV3 robot and software. The purpose of this study was to introduce the Lego Mindstorms EV3 robot used in programming education, to examine its software interface and to provide information about how to use it. **Keywords**: Lego Mindstorms EV3, robot programming, programming education, coding education, educational robot

1. INTRODUCTION

Today, programming skills have become an important field of proficiency not only for people who work with computers but for all people from any professional area. The reason is that programming skills make important contributions to productivity and creativity. As the importance of programming skills has increased, the number of people who need these skills has increased as well, which has resulted in giving programming education to people at all ages (Demirer and Sak, 2016). Consequently, specific coding education materials have been developed for all ages and for all education levels.

As a general concern about programming, it is considered to be difficult and complicated. It is obvious that it is not easy to learn programming and that various difficulties are experienced in the process of being successful in programming courses (İmal and Eser, 2009; Başer, 2013; Saygıner and Tüzün, 2017). In order to overcome these difficulties, use of block-based visual programming languages is suggested. In one study, it was revealed that individuals can easily learn the logic behind programming and the concepts related to programming with the method of the drag-and-drop code blocks and that this method is user-friendly with its positive influence on individuals' motivation in programming (Yükseltürk, Altıok, 2016).

Although there are a large number of studies conducted to spread robot education throughout the world, related studies conducted in Turkey are still rare in number. Studies and written sources regarding especially technological issues become out-of-date until they have been translated into Turkish, and in the process, the technology in question is replaced by another one. Throughout the world, there are now enough sources regarding the basic use and user-friendliness of the robot kit for interested researchers, teachers and students who are willing to use it. The purpose of the present study was to introduce the Lego Mindstorms EV3 robot used in programming education, to examine its software interface and to provide information about how to use it. Therefore, in the present study, a new and gradually-popular technology product, Lego Mindstorms EV3 robot and the blocks in its software interface were examined. Also, its use was elaborated by designing sample softwares.

2. LITERATURE

Today, the interest in programming has increased, and this interest has not been limited just to people working with computers but it has become a field of competence for all individuals. People are suggested to take programming education so that they can develop new projects using different technologies (Akpınar and Altun, 2014; Çakıroğlu, Sarı and Akkan, 2011). The most important reason is that programming education is considered to be beneficial for problem solving, for algorithmic thinking and for the development of creativity (Yünkül, Durak, Çankaya and Mısırlı, 2017). With the supports of governments and of various foundations in private industry, programming education has been initiated for individuals at all ages (Demirer and Sak, 2016). Programming education has become so wide-spread that coding classes, STEM (Science, Technology, Education and Mathematics) laboratories, robotic education areas have been opened at schools. As a result of these developments, programming languages and materials appropriate for all ages have been developed.

Without having to use any code for young students, drag-and-drop programming languages similar to the logic of jigsaw have been developed. These types of environments are called Block Programming, and Scrath, Code.org, Kodulab and App Inventor can be given as examples of these environments. In most of these environments, the logic and fundamentals of programming can be taught easily via simple tasks assigned to individuals (Code.org, 2017; Scratch, 2017; Kodulab, 2017). Recent studies have demonstrated that such visual programming environments such as Scratch, Lego Mindstorm and Alice considerably decrease the inefficiency and difficulty in learning programming for beginner-level information technologies. As visual programming environments provide a simple, exciting and entertaining atmosphere, they seem to be more appealing when compared to text-based programming environments (Schwartz, Stagner & Morrison, 2006; Lamb & Johnson, 2011; Lin & Liu, 2012).

Learning programming requires development of a different mentality. In programming languages, concretization will make it easier to minimize the negative influence of working with abstract concepts and to better understand the underlying logic. Therefore, use of

platforms like Arduino in programming education will facilitate things on behalf of students and avoid facing difficulty since these platforms will provide concrete feedback in relation to the codes (Ersoy, Madran and Gülbahar, 2016). Using the signals sent by sensors, Arduino is a physical programming platform to develop systems and robots which interact with the environment (Robotistan,2017). In one study carried out by Hubwieser, Giannakos and Berges (2015) at secondary school level in 12 countries, computer science curricula. The study summarized the objectives of the education, related competencies, course contents and the programming languages and environments were examined. The results of the study revealed that the programming tools popular in the 12 countries included hardware systems like Lego Mindstorms and Raspberry Pi. In another study conducted with secondary school students in Turkey, it was reported that all the participants preferred programming education given with robots to traditional programming (Çankaya, Durak, Yünkül, 2017).

Considering the fact that robots are increasingly prevalent in our lives today, it is now an inevitable need to use them in education. In many countries, robots are currently in use in such courses as mathematics and science and technology besides robot education (Fidan and Yalçın, 2012). Mindstorms EV3, Parallax Robotics Kits, MakeBlock Kits and Robo Mind can be given as examples of these tools. Most of these tools have their own specific languages, yet they all support such common languages as C#, C++, Python and Java as well (ev3dev.org, 2017).

3. LEGO MINDSTORMS EV3 PROGRAMMABLE ROBOT KIT

The Lego Mindstorms EV3 model examined in the study is widely used not only because it can easily be structured but also because it allows multi-faceted use. For this reason, it was selected to provide a source for researchers, students and teachers. The software of Lego Mindstorms EV3 Home Edition aims to make use of all the features provided by the robot. The software is quite easy to install and use. In addition, among its other alternatives, the software is popular due to its software interface which does not restrict its users.

3.1. Features of LEGO Mindstorms EV3

The Lego brick is the part that controls all the parts of the robot. This part includes slots for USB, SD card and charger and eight ports to connect the engines and sensors. In addition, a small-size screen and the buttons allow controlling it when not connected to a computer. The basic set of Lego EV3 includes:
1. EV3 intelligent brick
2. Three servo engines
3. One gyro sensor
4. One touch sensor
5. One color sensor
6. One ultrasonic sensor
7. Hardware parts to use for the construction of the robot (Lego, 2017).

Figure 1. Main Equipment Parts of Lego Mindstorms EV3 Education Set.

3.2. Features of LEGO Mindstorms EV3

After the parts of the robot are assembled as appropriate to the intended function, it should be programmed with the help of its own software (Lego, 2017). The software provided by Lego has quite an easy and user-friendly interface. Though it is easy to use, it can be used in many areas for various purposes. As long as the number of parts is sufficient, a robot which can serve multi-functions can be developed. In addition, programs were developed to examine the working principles of all sensors in detail. Also, samples including basic programming concepts were prepared and tested. For this purpose, the Mindstorms EV3 Home Edition 1.2.2 version was used.
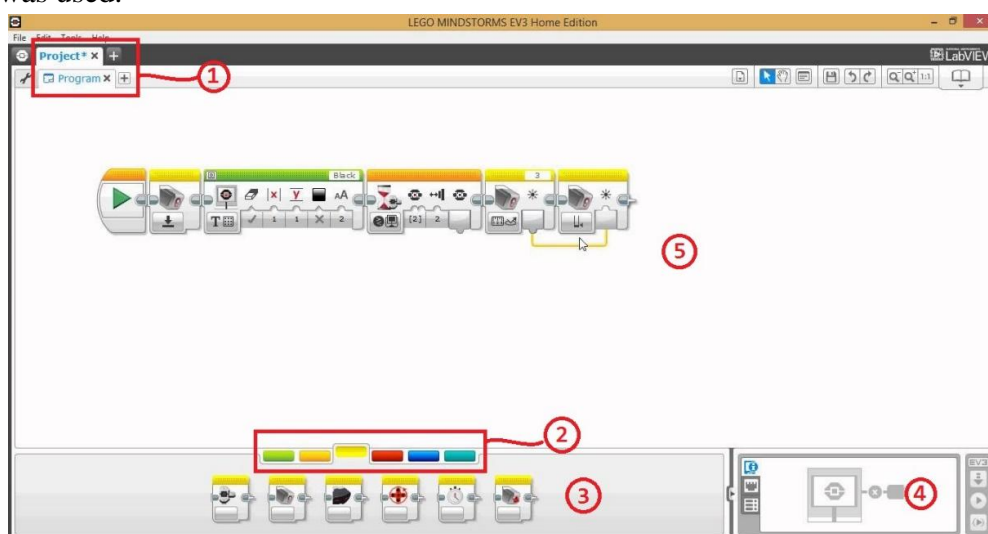
Figure 2. Lego Mindstorms EV3 Home Edition Software Interface

When the software interface is opened, the image in Figure 2 appears on the screen. The project and the programs in the project can be seen in section 1. Section 3 below includes the blocks to be used for programming. Section 2 presents the categories of blocks to be used. In section 4, the robot and the sensor values of the robot can be seen. Section 5 is where we can use the blocks with the drag-and-drop feature and form our program. The program can be developed by just using the drag-and-drop method without any knowledge of coding.

3.3. Robot Design

In the design, a totally personal method should be applied on the basis of one's needs. The robot in Figure 3, which is also found in the basic set guideline, was developed for the use of all the sensors and motors together with the parts in the Lego EV3 Basic Set. It does not have a specific shape, and it should be customized totally in line with the purpose. Therefore, before the designing process, it is necessary to determine for what purpose the robot will be used.

Figure 3. The robot developed

4. LEGO MINDSTORMS EV3 SOFTWARE INTERFACE

Lego EV3 works on block programming. The blocks to be used were gathered in five main sections: action, flow, sensor, data operations and advanced. Also, there is a tab called 'my blocks'. In this tab, the programmer can design blocks on their own as in objective programming.

Table 1. Variable structures used in the block structure.

| Shape	Meaning
	Descender at the bottom: Outputs a value.
	Descender at the top: Inputs a value.
	Round descender: Inputs or outputs an integer value.
	Square descender: Inputs or outputs a text value.
	Triangle descender: Inputs or outputs a boolean value. Takes a correct or wrong value
	Two descenders: Shows an array. They keep the above meanings for the round, square or triangle.

4.1. Action Blocks
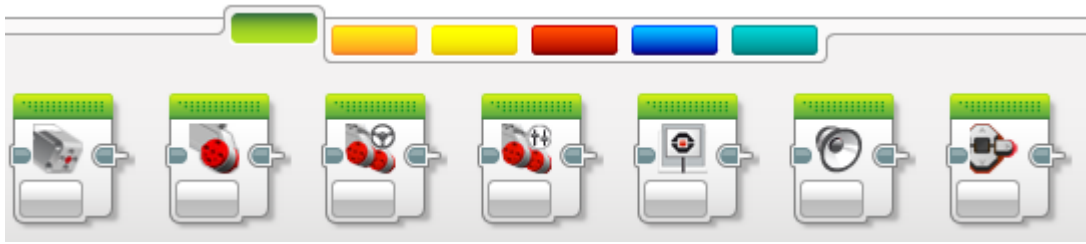
Figure 4. Action Blocks Menu

Action blocks allow controlling the movement of the robot with engines, its sound, its screen and the lights around the buttons under the screen. The action blocks also make it possible to control the physical functions of the robot.

Table 2. Action Blocks and Their Definitions

DEFINITION	BLOCK
Engines The engines are generally similar in terms of their use. We determine parameters for the command, power and number of revolutions and command and determine whether the engines will break when it ends. In addition, the commands can be set as power on/off for seconds, degrees and rotations. At the right top, the name of the port can be seen.	
Medium Motor The medium motor is the one that the lever is connected to in the robot we have designed. As it has a lower level of power when compared to large motors, it is generally used in this or similar forms.	
Large Motor These motors have the same principle of working as the medium motors. When compared to medium motors, large motors are powerful and two in number in each set. Therefore, they are generally used to give the power to tyres.	
Move Steering It allows controlling two large motors with a single block. As can be understood from the symbol of steering, it helps determine the direction of the movement of the robot. Also, we can determine the speed and rotation of the motors.	

DEFINITION	BLOCK

Move Tank

Similar to move steering, it allows controlling two large motors. We can separately control the power transmitted to the motors rather than determining the direction.

Display

It allows controlling the display above the intelligent brick. We can put images, figures and texts on the display. The images, figures and texts are determined, and the x-and-y coordinates are set. We can clear the display before doing something else. In the motors, at the right top is the port which the motor is connected to, and on the display block is the name of the figure or that of the image and the text to be written.
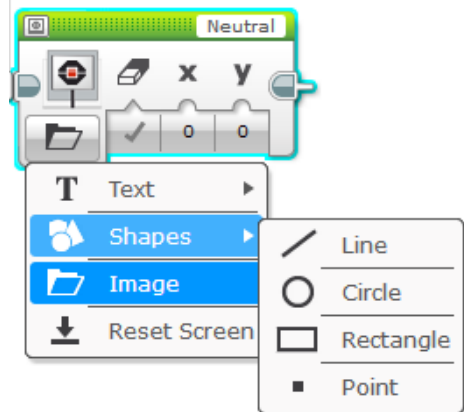
Voice

It allows controlling the voices. After selecting the file to be played, the tone or the musical note, we select the volume and what it will do at the end. When it ends, it can stop, replay or continues to play until it is stopped within the program. As in the display, we can select the audio file, the musical note or the tone on the right top.
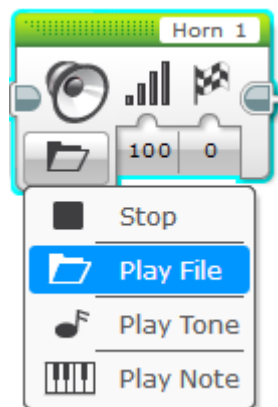
Brick Status Light

It allows controlling the lights behind the buttons on the intelligent brick. It can be selected as either on or off, and its color can be selected as yellow, green or red. We can determine whether it will only emit light or indicate a signal. It is generally used for warning in cases of certain conditions.
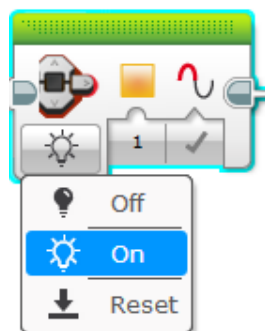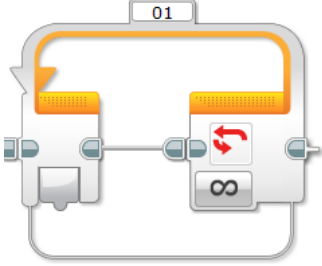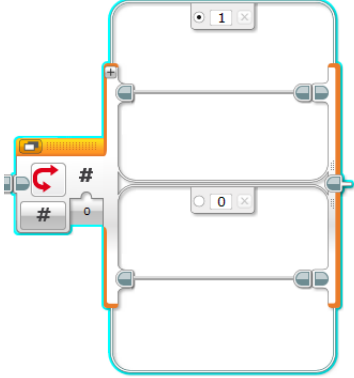
4.2. Flow Blocks

Figure 5. Flow Blocks Menu

Flow blocks allow managing the factors influential on the procedural structure by using the programming logic. These blocks help do the procedures of start, wait, loop, switch and loop interrupt.

Table 3. Action Blocks and Their Definitions

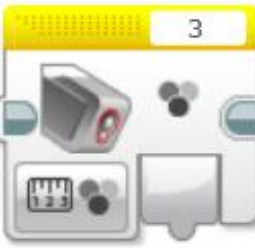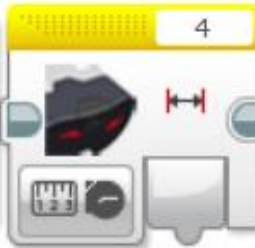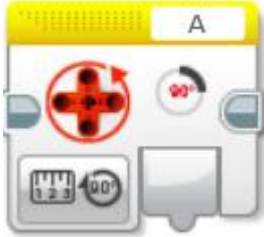| DEFINITION	BLOCK
Start This is the first block to work when the program is started. Any block added works next. When you want to do two or more procedures at the same time, you can give as many starting points as we want.	
Wait When it is time for the wait block, you cannot pass on to the next procedure until the specified time or procedure ends. The event can be determined based on the time, buttons or sensors.	
Loop For the repeating procedures, loops are used. Loops can either work depending on the time, number of repetitions, the result of the procedure, buttons or sensors or work everlastingly. In the case of working everlastingly, "interrupt" is used generally. Everlasting working is also used when you do not want the program to shut down automatically.	
Switch It is used when you want to do conditioned redirection or make changes in the flow of the program. While using the switch, a parameter is set for the condition, and new flows are determined for its possible values. The switch parameters can be the result of a procedure, buttons, sensors or a variable which shows a previously value-assigned integer, text or boolean value.	
Loop Interrupt This is the block that allows leaving the loop without providing any condition. In general, it is found in a switch, and when the specified conditions are achieved, it allows going out of the loop.	

4.3. Sensor Blocks
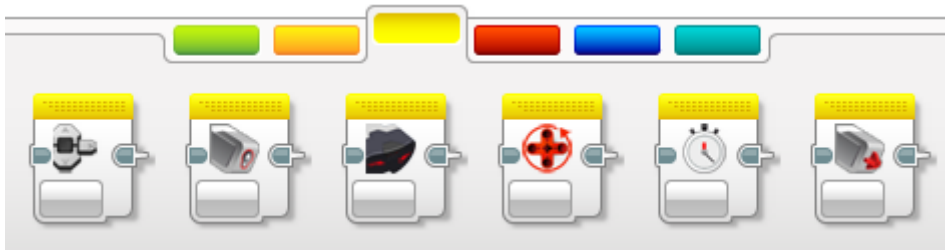
Figure 6. Sensor Blocks Menu

Sensors are the additional parts that allow the robot to obtain data from outside. The sensors are generally used in loops and switches. Since sensors can be used directly in an integrated manner in the loops and switches, there is generally no need to use these blocks. If the purpose is directly to read the value that the sensor reads, then sensor blocks are used for this purpose.

Table 4. Sensor Blocks and Their Definitions

DEFINITION	BLOCK
Brick Buttons It allows reading the value of the buttons found on the brick. Each button has a reference number. The block outputs the number that the button pushed belongs to. If more than one button is pushed, it outputs a serious of numbers.	
Color Sensor Each color in the color sensor has an integer value. It prints the numerical value instantly for the color it detects. When the color sensor is set, it could receive the reflected light or the light in the environment instead of the colors. Thanks to this, measurements like the day and night difference.	
Infrared Sensor The infrared sensor is used to measure the distance with the wall in front of the sensor or with any object. It can be used to stop before hitting an obstacle or to get directed towards a target.	

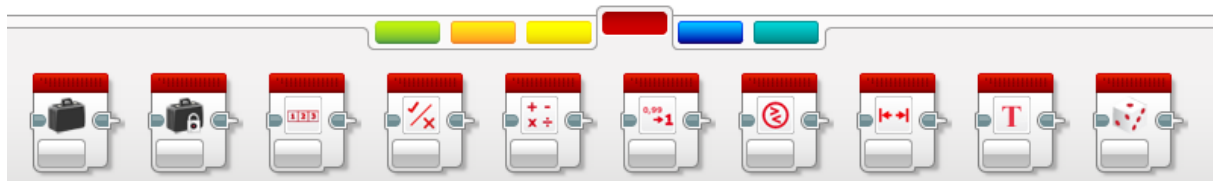| DEFINITION	BLOCK
Motor Rotation It allows reading the instant degree of the selected motor, its number of rotation and its power. Normally, we give these values in motors. However, these variables are complicated as programs become complex. Therefore, it is a needed block.	
Timer The timer is used to measure the time between the procedures or for the program to wait for the duration of certain procedures. When we have to do a time-based procedure, we define a timer, which works in the background.	
Touch Sensor We can use it not only like a remote controller but also to do a new task in case of an obstacle. It can be used in three ways: the pushed button, the released button released, and push-and-release button.	

4.4. Data Processing Blocks
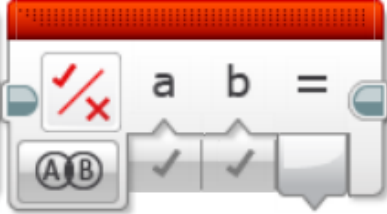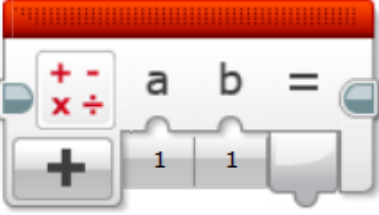
Figure 7. Data Processing Blocks Menu

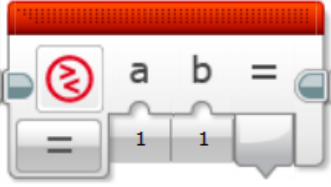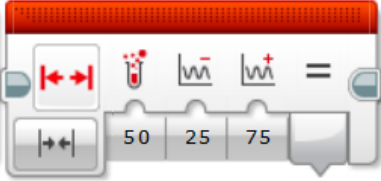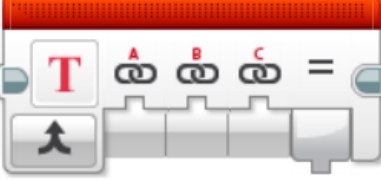The definition of arrays, constants, variables and many other procedures to be done while doing programming are done by using data processing blocks. It is necessary to make certain related definitions. For the definition of the values to be used in the program, variables are used if the value is to change, and constants are used if the value is constant. If we want an object to keep a record of several numbers separately; to illustrate, if we make a definition for colors and want to keep the colors of red and blue, then we need to define an array called colors. The first element of this array can be used as red and the second as blue.

Table 5. Data Processing Blocks and Their Definitions

DEFINITION	BLOCK
Variable Variables are defined and recorded for values like boolean, texts and integers to be used in programming. Thanks to this block, a value can be assigned by defining a variable, and the value of a defined variable can be read.	
Constant Some variables like the Pi number in Mathematics never change. These unchanging definitions are called constants. This block is used to define a constant and to read the value of a defined constant.	
Array Operations Arrows allow keeping a number of values in a single variable. This block is used to add an element to an arrow or to remove it from the arrow.	
Logic Operations Consequently, procedures returning as boolean value are called logical procedures. In general, it is used to check whether the specified conditions have been met or not.	
Math It is a block that allows doing mathematical procedures. The result is calculated by defining a special procedure like addition, subtraction, multiplication, division, absolute value, square root and exponent.	
Round It allows rounding fractional numbers to the closest lower or higher integer, and the closest value is found. It is preferred in cases which do not require elaborated calculation.	
Compare It is a block returning the result as a boolean value by comparing whether one value is higher or lower than or equal to another value.	

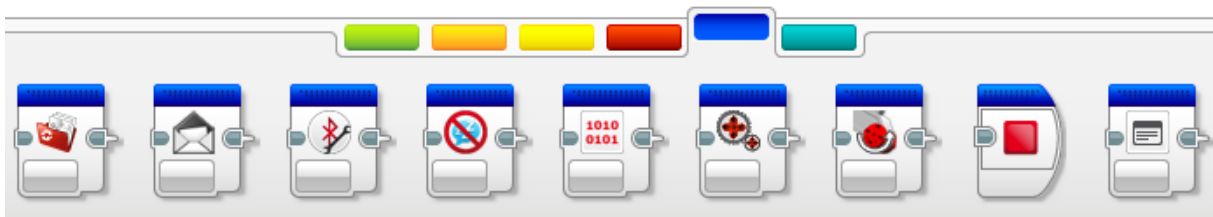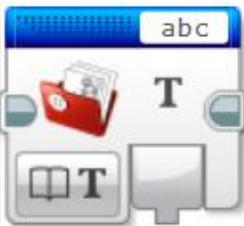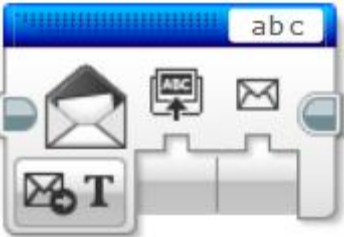| DEFINITION	BLOCK
Range It is a block which checks whether the value is in the specified range and which returns the result as a boolean value.	
Text This is a block that allows combining the defined text variables. It is generally used to combine the constants and variables.	
Random It gives a random result for a boolean value by entering a percentage or a number in the specified range.	

4.5. Advanced Blocks
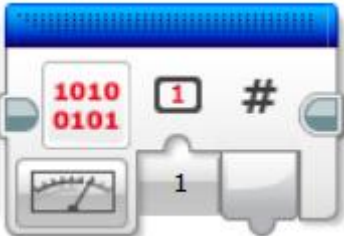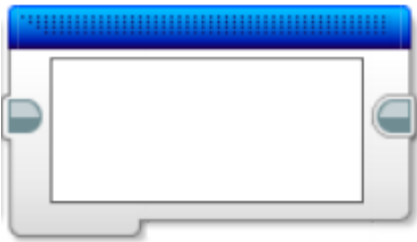
Figure 8. Advanced Blocks Menu

Procedures which will actually be mostly necessary for advanced programming and which are thus not needed in general can be seen in the tab of advanced.

Table 6. Advanced Blocks and Their Definitions

DEFINITION	BLOCK

File Access

The file access block is used to delete the file we have uploaded to the robot, to read a variable in the file, to write in the file and to close an open file.

Messaging

The messaging block allows the robot to send a message or to read and evaluate a received message. Also, the message received is processed in this block.

Bluetooth

This is a block that allows to activate and deactivate the bluetooth feature of the robot, to connect another device via bluetooth or to end a current connection.

Keep Awake

This block allows keeping a value regarding how long the device has been working.
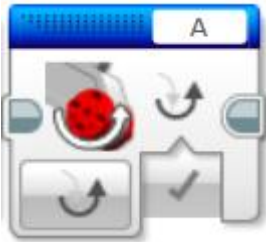
Raw Sensor Value

It shows the instant value that the sensor has in the selected port.

Unregulated Motor

It allows updating the power of the motor in the selected port. It is used when it is necessary to change only the power without changing any other value.

DEFINITION	BLOCK
Convert Motor It allows changing the direction of the motor in the selected port. It is used when it is necessary to change only the direction without changing any other value.	
Stop Program It is used to determine the end of the program. It is generally not used as the program will stop when the procedures are completed.	
Comment There is a need for adding a comment line between commands in big projects. This need can be met thanks to a comment block in block programming. It does not have any effect on the program.	

4.6. Sample Applications

Motor Control: It moves the lever in front of the robot up and down. It moves upwards slowly and downwards fast, and it repeats these movements five times.
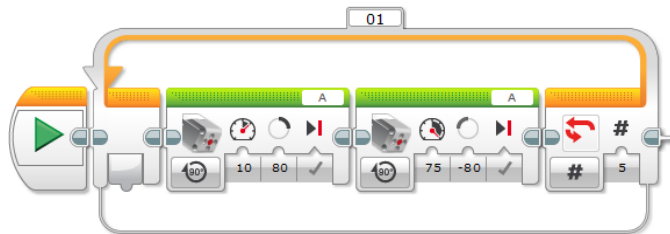

Figure 9. Sample Motor Control

Display Control: An animation of blinking has been formed in the display on the robot. Its eye is open for two seconds and closed for two seconds, and it has been programmed in a way to repeat this five times.
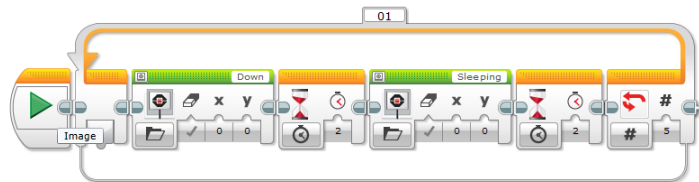
Figure 10. Sample Display Control

Movement Control with the Light Sensor: If the ground is red, the motors work with the light sensor placed with its face looking at the ground in front of the robot. It is repeated until the program is ended.
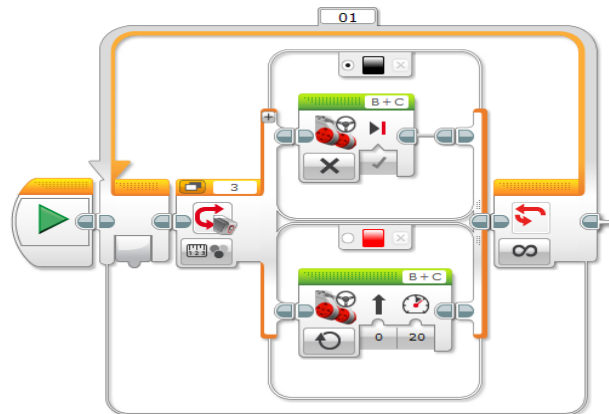
Figure 11. Sample Light Sensor

Movement control according to the distance with the infrared sensor: Thanks to the infrared sensors in front of the robot, it detects the obstacle and stops the movement if there is an obstacle in a distance of five centimeters. In other words, if there is no obstacle, the movement continues. It is repeated until the program is ended.
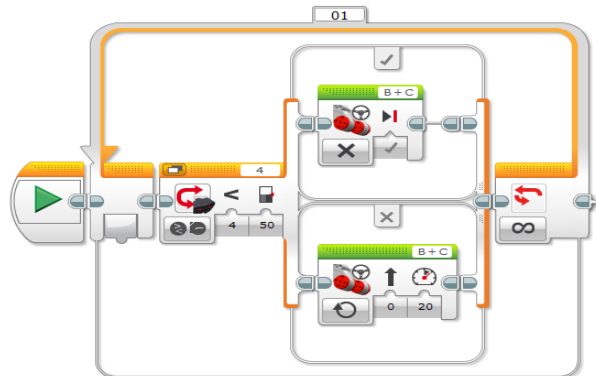
Figure 12. Sample Infrared Sensor

Movement control with the touch sensor: It stops when the touch sensor is pressed, and it continues its movement if not. The touch sensor can be used when it hits an obstacle, and we can take and control it in our hands like a remote controller.
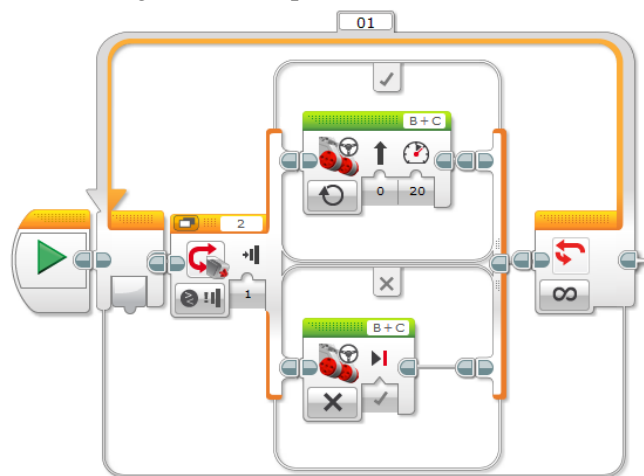
Figure 13. Sample Touch Sensor

Addition: It is a program that adds two entered numbers and shows on the display. First, two variables named a and b, and then values are assigned. Following this, the values are read and subjected to the procedure of addition. The result obtained is shown on the display.
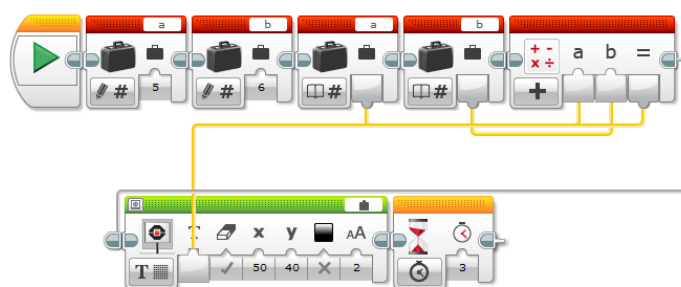
Figure 14. Program for Addition

5. CONCLUSION AND SUGGESTIONS

When the Lego Mindstorms EV3 robot education set is examined, it is seen that it is quite easy to install and use it. In addition, as the parts in the set are compatible with each other, the individual who formed a robot with the Lego Mindstorms EV3 robot set does not experience and problem of incompatibility between the parts when compared to other alternative robot sets. The robot can obtain information from the environment with the help of the sensors. Also, it can provide feedback via sounds, light and movement. Its additional features like data storage and calculation via data processing broadens its area of use.

In contrast with the related bias, it is fairly entertaining and instructional to design and code a robot with the Lego Mindstorms EV3 robot education set. In traditional programming languages, the software design and commands to be learned make learning rather difficult and require a long process. Block programming allows using an easier software design without any need for memorizing commands. Thanks to this, an individual who does not have any knowledge of programming can do coding easily with the help of the Lego interface. As can be seen in the sample applications, the coder has a good command of program hierarchy and flow when compared to traditional programming. In order to start programming education, the Lego Mindstorms EV3 robot education set will accelerate learning and make it more entertaining thanks to the visual quality of the program design and blocks as well as to user-friendliness of the interface. In addition, as the parts are in the form of jigsaw puzzle, it could be stated that elementary school students taking education with this set will develop their scientific and mathematical thinking and intelligence.

Within the scope of the present study, the influence of coding interface, not that of Lego EV3, on learning and teaching processes and its usability in coding education were examined. For this purpose, sample programs were developed and tested on the robot. In this respect, the study aimed to draw attention to a relatively new technology used in programming education, to introduce it to teachers and researchers and to prepare a guideline for those willing to use it.

The Lego Mindstorms EV3 robot education set is prominent with its features such as user-friendliness, compatible parts and the easy-to-understand coding screen when compared to other coding tools and robot sets. Thanks to these features, its use in the courses of robotics and coding newly included in education is thought to produce positive results, as can be seen in related studies in literature, and to be influential on increasing students' motivation and interest in coding.

Lego Mindstorms Ev3 Robot Programlama Arayüzünün İncelenmesi

Özet

Günümüzde programlama eğitiminin değeri giderek arttığı ve bu eğitimin ilkokul düzeyinde verilmeye başladığı görülmüştür. Bununla paralel olarak programlama araçları da çeşitlilik kazanmıştır. Klasik programlama eğitiminin yeni başlayanlar ve özellikle yaşı küçük çocuklar için zor olabilmesi nedeniyle blok programlama dilleri geliştirilmiştir. Blok programlama şeklinde yeni başlayan öğrenenler programlama öğrenmeye daha kolay adapte olmaktadır. Programlama eğitiminin yaygınlaşmasıyla blok programlama da gelişmiş ve robotların bloklarla programlanması için birçok dil ve materyal geliştirilmiştir. Bunlar arasında en yaygın olarak kullanılanlardan biri Lego Mindstorms EV3 robotu ve yazılımı olmuştur. Bu çalışmanın amacı programlama eğitiminde kullanılan Lego Mindstorms EV3 robotunu tanıtmak, programlama arayüzünü incelemek ve nasıl kullanılabileceğine yönelik bilgiler vermektir.

Anahtar Kelimeler: Lego Mindstorms EV3, robot programlama, programlama eğitimi, kodlama eğitimi, eğitsel robot

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