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Research Article

Coding, Robotics and Computational Thinking in Preschool Education: The Design of Magne-Board

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Abstract

The coding education given within the scope of STEM (Science, Technology, Engineering, and Mathematics) education gives children computational thinking skills. Computational thinking involves a set of problem-solving, algorithmically thinking, analytical thinking and critical thinking skills. When the coding education is given to children by an ER (Educational Robotics), the content of the education becomes more tangible and fun. In addition, ER helps develop motor skills and hand-eye coordination. It supports children's social development by directing them to collaboration and teamwork. In this study, an educational coding robot with magnetic board that makes the coding education suitable for preschool children was designed. This platform has attractive visual design, audible and illuminated warnings. In addition, it is computer-independent, easily portable and can be operated wirelessly. The educational robot was introduced for use by 40 children aged 4-5 years old. The interaction of the children with the robot was observed by 10 people in total, consisting of pre-school teachers and academicians. An evaluation form containing open-ended questions has been created to evaluate whether the prepared educational robot is a useful material for teaching pre-school children. Answers and suggestions from users were recorded and interpreted according to content analysis. It was determined that the educational coding robot with magnetic platform developed according to the obtained data is suitable for the pedagogical properties of the target group. In addition, it is concluded that there is an educational material that can be used for the expected purpose.

Keywords: Coding education, Computational thinking, Educational Robotics, STEM.

Okulöncesi Eğitimde Kodlama, Robotik ve Bilişimsel Düşünme: Magne-Board'un Gelişimi

Öz

STEM (Science, Technology, Engineering, and Mathematics - Fen, Teknoloji, Mühendislik ve Matematik) eğitimi kapsamında verilen kodlama eğitimi, çocuklara bilişimsel düşünme becerileri kazandırmaktadır. Bilişimsel düşünme, bir dizi problem çözme, algoritmik düşünme, analitik düşünme ve eleştirel düşünme becerilerini içerir. Çocuklara kodlama eğitimi ER (Educational Robotics – Eğitici Robotlar) tarafından verildiğinde eğitimin içeriği daha somut ve eğlenceli hale gelir. Ek olarak, ER motor becerilerin ve el-göz koordinasyonunun geliştirilmesine yardımcı olur. Çocukları işbirliğine ve ekip çalışmasına yönlendirerek sosyal gelişimini destekler. Bu çalışmada kodlama eğitimini okul öncesi çocuklara uygun hale getiren manyetik kartlı eğitici bir kodlama robotu tasarlanmıştır. Bu platform çekici görsel tasarıma, sesli ve ışıklı uyarılara sahiptir. Ayrıca bilgisayardan bağımsızdır, kolayca taşınabilir ve kablosuz olarak çalıştırılabilir. Eğitim robotu 4-5 yaş arası 40 çocuğun kullanımına sunuldu. Çocukların robotla etkileşimi okul öncesi öğretmenleri ve akademisyenlerden oluşan toplam 10 kişi tarafından gözlemlendi. Hazırlanan eğitim robotun okul öncesi çocuklara öğretmek için yararlı bir materyal olup olmadığını değerlendirmek için açık uçlu sorular içeren bir değerlendirme formu oluşturuldu. Kullanıcılardan gelen cevap ve öneriler kayıt altına alındı ve içerik analizine göre yorumlandı. Elde edilen verilere göre geliştirilen manyetik platformlu eğitici kodlama robotunun hedef grubun pedagojik özelliklerine uygun olduğu belirlendi. Ayrıca beklenen amaç için kullanılabilecek bir eğitim materyali olduğu sonucuna ulaşıldı.

Anahtar Kelimeler: Kodlama Eğitimi, Bilişimsel Düşünme, Eğitici Robotik, STEM.

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1. Introduction

Until recently, developments in the field of technology make it necessary to educate people who can use this technology and carry it forward. For this purpose, more emphasis has been placed on science, technology, engineering, and mathematics (STEM) education for children around the world recently (Gelman & Brenneman, 2004). In addition, new technology learning standards and technology integrated applications have been developed (Barron et al., 2011; Marina Umaschi Bers et al., 2014)

In the past years, it has focused on advanced schools for robotics and programming, and educational studies carried out within the scope of STEM education. After the idea "this education could be a useful experience for preschool children" proposed by Bers in 2008, STEM education has been started for preschool children (Marina Umaschi Bers, 2008). ER used in this education are new generation educational tools developed for children to understand mathematical concepts such as number, shape, and size more easily (Brosterman, 1997; Resnick et al., 1998). In this way, children were provided to transform the concepts of abstract mathematics and science into concrete real-world applications (Karim et al., 2015). In addition to providing a fun educational environment, ERs improve fine motor skills and hand-eye coordination. It also supports children's social development by directing them to collaboration and teamwork (K. T. H. Lee et al., 2013; Ortega et al., 2009; Schneider et al., 2011).

There are supporting studies in the literature that are suitable for starting robotic and coding education at the age of 4 (Marina U Bers et al., 2002; Cejka et al., 2006; Perlman, 1976; Sullivan et al., 2013; Sullivan & Bers, 2016; Wyeth, 2008). These studies also draw attention to the fact that children exposed to STEM curricula and coding education at an early age have less gender stereotypes about their STEM careers and less obstacles to technical fields. In addition to the positive benefits mentioned above, early coding education also contributes to the mental development of the child. According to the idea which created by Jeanette Wing in 2008, robotics and coding education supports "the computational thinking" ability in early child (Wing, 2006). This term can be explained as a broad analytical and problem-solving skill and tendency used in computer science (Barr & Stephenson, 2011; I. Lee et al., 2011). Coding education makes individuals gain creative thinking, algorithmically thinking, analytical thinking, critical thinking, problem solving and design-focused thinking abilities.

The first study on coding education goes back to the 1960s. With the Logo language developed by Seymour Papert and MIT researchers, children were given the opportunity to program the movements of a turtle. In this way, the children were able to create new ideas in mathematics and science (Papert, 1980).

Based on Papert's views on constructivism, several programming languages have been developed for children and novice users (Kelleher & Pausch, 2005). At the beginning, the programming tools were based on text and graphical user interfaces (GUIs). Some of the notable GUI based user interfaces were Alice (Conway et al., 1994), ToonTalk (Kahn, 1999), RoBoLab (Portsmore, 1999), and Scratch (Resnick, 2007). These graphical interfaces allow children to program by using icons on the computer screen. However, the programming process with GUI-based interfaces requires the ability to match the symbolic representation on the screen with the actions they produce (Sapounidis & Demetriadis, 2011) has some difficulties for beginners of all ages.

Tangible user interface (TUI) based languages have been developed to solve these problems. TUI creates an environment for users without a mouse and keyboard and allows programming with physical objects such as puzzles and cubes (Smith, 2007). Subsequently, TUI-based studies began to become a very attractive field of research for the scientist.

Tangible languages are also used to program educational robots (ER). ERs are a multidisciplinary educational nature that provides constructive learning environments for a better understanding of more scientific and non-scientific topics. They play an important role in learning the subjects of Science, Technology, Engineering, and Mathematics (Dwyer et al., 1991; Jeschke et al., 2008). The Tortis-Slot machine is the first tangible robot system when tangible languages for robotic programming are placed in chronological order.

The Tortis-Slot machine is the first tangible robot system. This system, consisting of a 3-color card, turtle robot and slot machine, was designed by Perlman. Tangible Programming for trains created in 1998 by Genee Lyn Colobong and Martin. This language became commercial product by LEGO in 2003 as the "Lego intelli – train". Tangible Programming Bricks was designed by McNerney. Electronic Blocks - roBlocks were designed by Peta Wyeth and Helen C. Purchase. Children can create programmable little robotic vehicles and simple constructions by stacking the electronic blocks one on top the other. In the continuation of these studies Gameblocks, Tern – Tangicons, the PROTEAS (Programming Tangible Activity System) kit, Algorithmic Bricks, Dr. Wagon, Robo-Blocks, KIBO, T-Maze, E-Blocks, TanProRobot, Primo, and Code-a-pillar are taken place in the literature (Alimisis et al., 2017). Despite the various design approaches, there are different opinions about the advantages and disadvantages of using such TUIs or GUIs. Some studies have argued that TUIs are more natural and user-friendly than GUIs (Ishii & Ullmer, 1997). In another study by Sapounidis et al, they compared TUI and GUI to program a robot. They explained that the result depends on the age and gender of the children (Sapounidis & Demetriadis, 2013).

In this study, an educational coding robot with magnetic board was created which makes this education convenient for the preschool children. This robot which designed to support computational thinking skills, consists of three main part called play mat, magne-board (coding board) and mobile robot. It provides a pleasant independent education environment with its easy-to-carry feature, audible and sound alerts and moving parts. It also provides an effective environment for the child to produce a solution to the problems he/she faces, to see the results, correct his mistakes and enjoy the happiness of his success.

A group of 40 children between the ages of 4 and 5 was created to test this educational robot. The robot was introduced to the children and the situations they could do with this robot were explained. The reason for choosing children at this age is that 4-year-olds are specified as the appropriate age to start coding education. Ten volunteer observers, consisting of pre-school teachers and academicians, have been identified to observe the interaction of children with the robot. As a result of the observations, "Did you find this educational robot useful for code the training? (Why?)", "Is the educational robot suitable for the developmental characteristics of the target audience? "And" What effect do you think learning coding had on children? " teachers and academics were asked and their suggestions were taken.

The robot designed according to the answers was evaluated. The statements given in the answers were summarized with the context analysis technique and interpreted. The findings were categorized and scored as sub-themes and main themes. Findings and suggestions of the observers are explained in the conclusion section.

2. Material

2.1. Design Features

It is necessary to pay attention to the physical characteristics of the design, especially if you want to design an educational robot for children (Barnes et al., 2020; Chu et al., 2019). Because physical properties can strongly influence the way children perceive and use it (Yu & Roque, 2018). This educational robot is consisted of 3 fundamental components, namely “motion platform”, “magne-board (coding board)” and “traveler robot”. All the mechanical parts were drawn in SolidWorks and the parts were created through 3D printer.

The used PLA (polyactic acid) material is an organic one that is produced from corn starch and sugar cane. This material, which is preferred because it is not dangerous for health, has a bright and clear appearance. The main color used in the robot is bright orange. The training robot has audibled and illuminated alerts to handle multiple senses. The current physical features attract children's attention, increase their interest and curiosity. It also encourages children to use the material. The basic parts of the educational robot are as follows.

2.2. Playground

The motion platform is 65x65 in size and consists of 16 cells. In this platform, children are asked to determine the starting position of the robot and then the target location of the robot. The children plan the necessary steps to ensure that the robot travels from the starting position to the target location in their mind. As a result of these plans, the magne-board, steering blocks, and playground are used to make the desired movement to the mobile robot. This process followed by children is the stage of creating an algorithm, which is the first step of writing code. The successes to be gained by building different stories and games can be increased with the themes in the motion platform. The playground is given in Figure 1.

Photos on the playground are some of Turkey's historic and tourist places. These are Pamukkale travertines, Cappadocia, Potbelly Hill temple, Mount Nemrut, Ephesus ancient city, Troy ancient city, Hierapolis ancient city. Thus, teaching the historical and touristic places in our country becomes easier.

2.3. Magne-board and steering blocks

The magnetic board is where the action plan is produced by the steering blocks. After determining the starting and target position of the robot on the playground, the movements towards the target are placed on the magne-board via steering blocks and then transferred to the mobile robot which can be accessed remotely. Commands are sent forward, backward, left, and right to the robot that is moved one cell at a time. These direction commands are created using steering blocks that can be placed and removed from the magne-board, like Legos. Communication between the steering blocks and the magne-board is provided by the magnets placed in the feet of the blocks and the reading reed relays in the magne-board. This cost-effective method does not require additional sensors. Magne-board and streering blocks designs are seen respectively in Figure 2 and Figure 3.

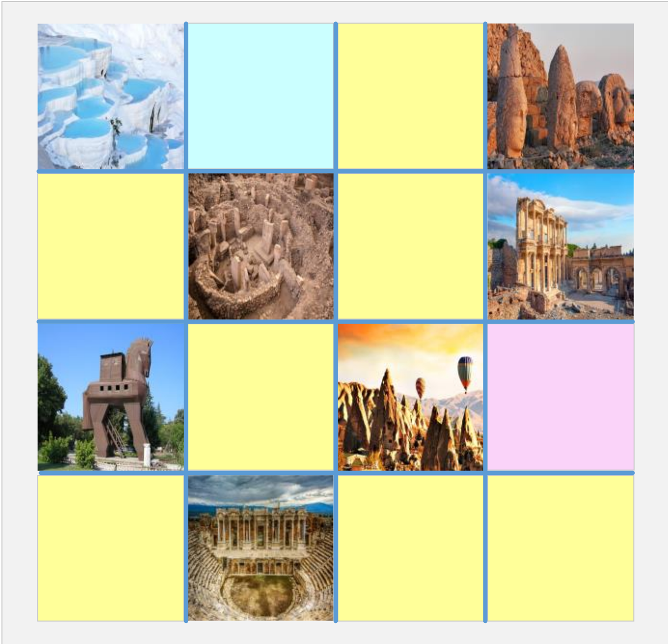

Figure 1. Playground.

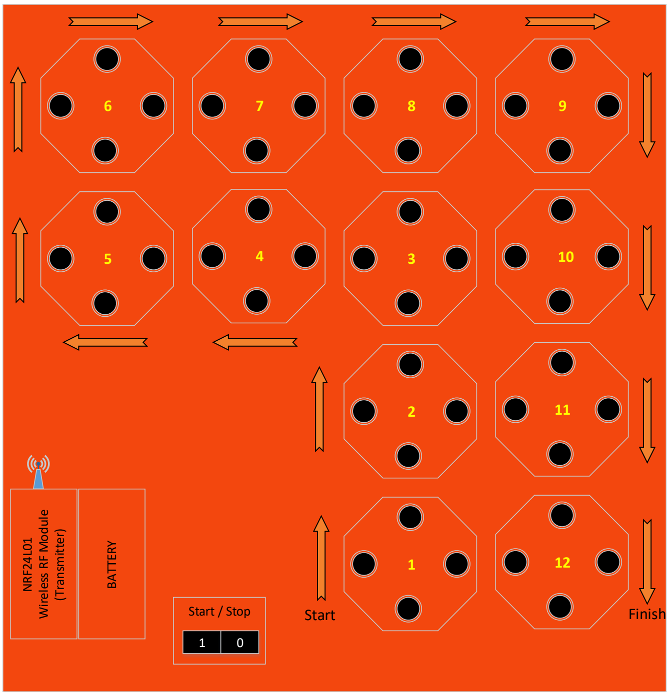

Figure 2. Magne-board design.

To start the movement, the steering blocks must be placed on the magne-board according to the directions of the arrows associated with the colors on it. Using the magne-board, the desired movement can be visualized in the minds of children. The electronic circuit diagram developed for the magnet-board is shown in Figure 4.

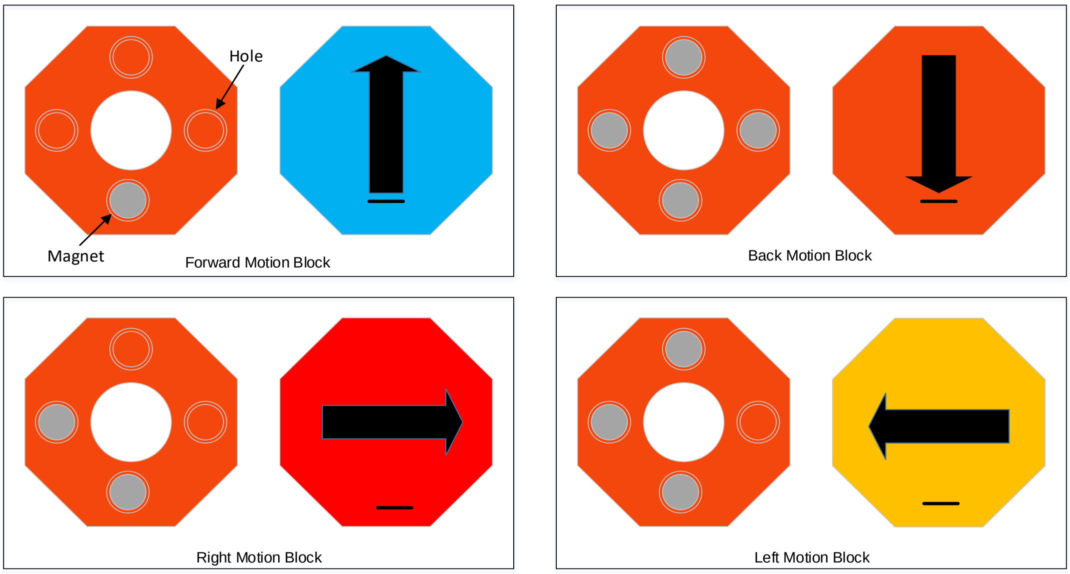

Figure 3. The top and bottom views of the steering blocks.

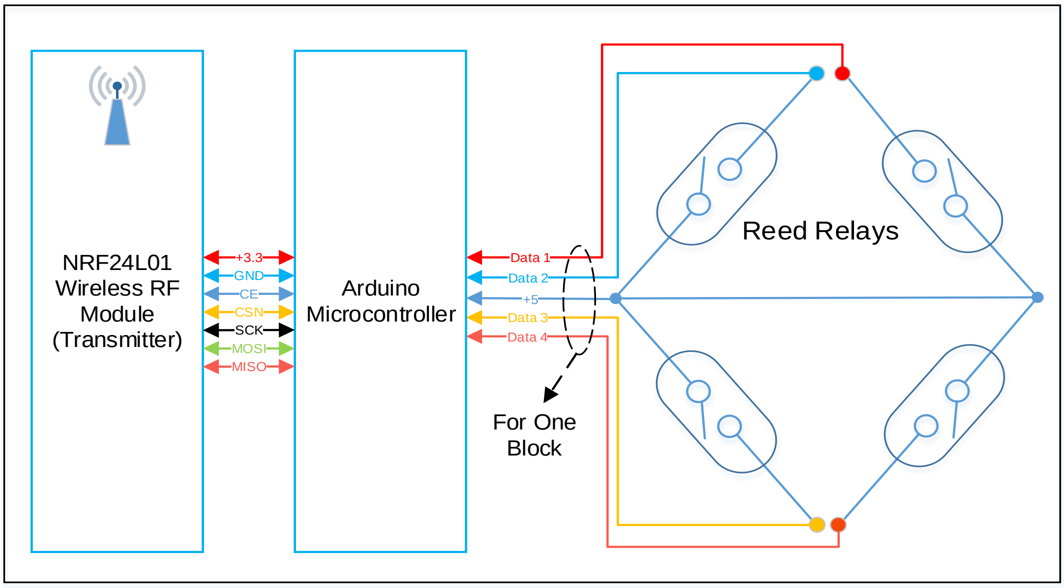

Figure 4. Electronic circuit diagram of the magnet-board.

2. 4. Mobile robot

The mobile robot, which is the moving part of the education platform, is 14 x 14 cm in size and has a colorful design that appeals to the age levels of children. The mobile robot detects the command given on the magne-board via wireless connection and performs its movements on the playground according to these commands. The robot has a sound notification. When it is operated, it says "hello", "let us go on a trip"; When it is stopped, it says "goodbye", "see you again". At the same time, the mobile robot has LEDs that look like an eye on the face. These LEDs, which turn off during standby, operate by blinking while the robot is in motion.

These stimuli allow the child to become familiar with the educational robot and have fun while learning. The size and weight of the educational robot are such that children can easily carry it. Since the communication between the magne-board and the robot is provided wirelessly, there is no wiring problem. Figure 5 shows the mobile robot developed.

Figure 5. Mobile robot.

While designing this educational material, the concept of computational thinking, which Jeanette M. Wing introduced in 2006, was taken into consideration. In this concept, the child thinks how to behave in the face of a problem, plans the steps towards a solution and reaches the result. What is expected from the child in this education robot is to plan the movement that will

carry the robot from one point to another on the playground and then create this movement plan that s/he creates in his/her mind with the steering blocks. The electronic circuit diagram developed for the mobile robot is shown in Figure 6.

3. Method

3.1. Participants

The aim of this study is to examine the effects of coding education robot designed for preschool children with the comments of preschool teachers and academicians who are experts in their fields. Within the scope of the research, the opinions, and suggestions of 4 teachers and 6 academicians about the coding training robot were revealed, and a qualitative research approach was used to evaluate these opinions and suggestions. The qualitative data obtained through interview and observation were analyzed and interpreted with descriptive and content analysis methods. In the test stage, the educational robot was tried by groups of preschool children aged 4 and 5. Each group were consisted of 20 students. Different preliminary studies were applied to them due to age differences and different experiences were presented with the robot. Experiments were conducted in classrooms that were offered by schools for this purpose (Figure 7).

3.2. Preliminary studies

Since the children had not received any coding education before, they were given training to start coding lessons in 2 sets of 30 minutes.

1. Set: With the colorful pillows that were placed on the floor, the children were made to play target-reaching games. (For instance, the discussion of how it is possible to start from the yellow pillow and reach the green one).

2. Set: In the second 30 minutes long set, the floor is divided into squares with chalk. With the arrow signs, having been prepared from colorful plates, signs were created on the floor and the children were asked to move by following the arrow signs. These preliminary studies were made to prepare the children for the situation that is intended to be made with the educational robot.

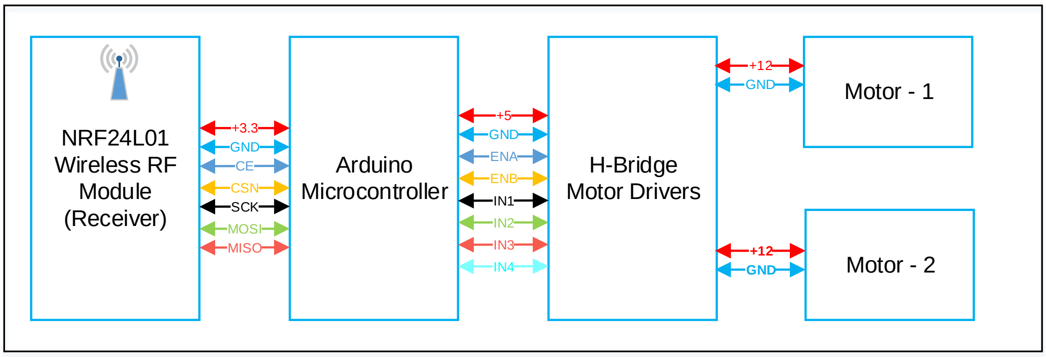

Figure 6. Electronic circuit diagram of the mobile robot.

Figure 7. One child coding the robot with Magne-Board.

3.3. Procedure-meeting with the coding education robot

After these preliminary studies, the children were introduced to the coding education robot. Showing suggestions to the views of the teachers, the group of 4-year-olds was started with the applications that they can use only the forward and left steering blocks. Later, the applications they can do by using the right and back steering blocks and lastly, the applications they can do by using all steering blocks are given. In this way, the functions of the educational robot are gradually presented to the 4-year-old age group. In the first stage, applications that can be done with forward, right, and left steering blocks were given to 5-year-old children, the other age group of the study. Afterwards, with the reverse routing block, it was explained that the routes they determined in the previous step can be reached in shorter ways to reach the target, and the 4 steering blocks of the education robot were used. Children's interaction with all parts of the robot, their level of perception and fulfillment of the tasks expected from them were observed and recorded by preschool teachers and academicians.

3.4. Data collection instruments

The semi-structured interview technique was used in the study. This technique was preferred because it provided more systematical and comparable knowledge, depending on the format prepared beforehand. These interviews were made by the researcher and created as the result of the literature review (Gültepe, 2018), and the answers to the following questions were sought:

1- Did you find this education robot that was made for coding education beneficial? (Why?)

2- Is the education robot suitable for the development characteristics of the target audience?

3- In your opinion, what kind of effect did learn to code have on children?

Finally, it was asked to the teachers whether they had recommendations toward the development of the coding education robot.

3.5. Data analysis

While the data were analyzed, the qualitative data that were gathered through interview and observation were interpreted by being analyzed with content analysis methods. Whereas descriptive analysis was a type of qualitative data analysis that includes the summary and interpretations of the data, which had been collected with various data collection techniques, according to predetermined themes, the fundamental goal in context analysis is to reach the concepts and relations that can explain the collected data. The reason why both analysis methods were preferred is that the unrealized concept and themes can be explained better by taking the data that were summarized and interpreted in the descriptive analysis through a deeper process.

4. Results and Discussion

Academics and preschool teachers were asked to observe the interaction of children with the educational robot. Questions were asked to them because of these observations. The answers were classified by creating the main themes and sub-themes as previously mentioned. As a result of the answers given to the column f numerically transferred. % column is the percentage of the comments obtained from 10 observers. As in Table 1, when asked the 1st question, it is seen that the coding education robot has positive aspects. In addition, graphical representation of results also is given in Figure 8.

Table 1. The positive aspects of the prepared material

Theme	Sub-themes	f	%
Utility	1. Usefulness	10	100
	2. Raising awareness	8	80
	3. Imagination development	6	60
	4. Sense of success	8	80
	5.Social responsibility	6	60
Productivity	6. Creating his/her own applications	5	50
	7. Producing solutions	9	90

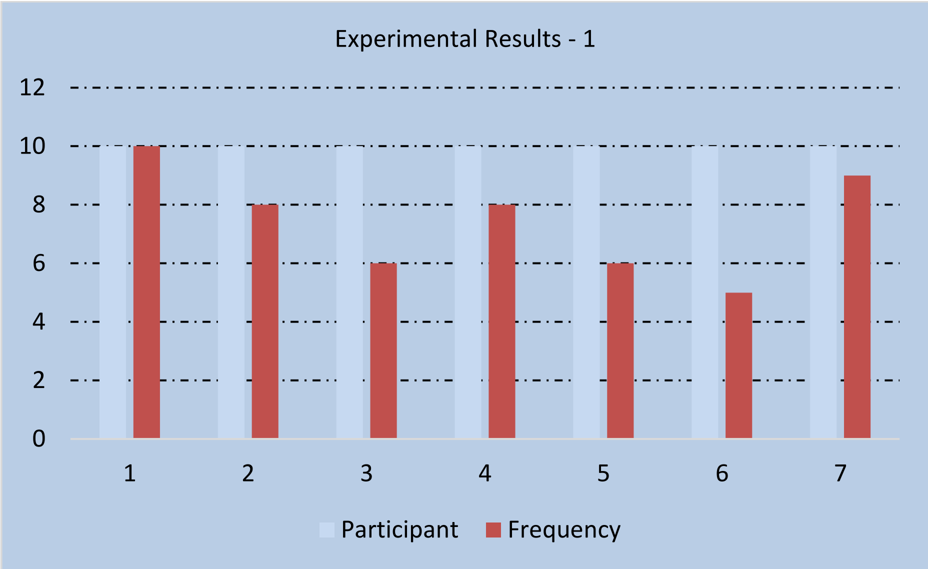

Figure 8. Graphical representation of results - 1.

These positive aspects were consisted of the main themes as utility and productivity. According to the results obtained from the positive effects table, it is concluded that the proposed material achieved an average success of 75% in these themes. The robot's being a helpful model to teach coding, creating curiosity and sense of accomplishment in children is thought. In addition, it is believed that preparing the children for the technological developments of today, providing them with the ability of problem solving, cause-effect relationship, analytical thinking and concrete thinking is a social responsibility. It is seen to be supporting productivity because it also directs children in terms of finding their own solutions for the problems that they encounter.

The views on the suitability of the education robot for the use of the target audience, meaning the preschool children at the ages of 4 and 5, are given in Table 2. In addition, graphical representation of experiment results also is given in Figure 9.

Table 2. The suitability of the prepared material

Theme	Sub-themes	f	%
Physical suitability	1. Raising interest and curiosity	10	100
	2. Providing an enjoyable environment	10	100
	3. Child health	10	100
Cognitive suitability	4. Comprehension	9	90
	5. Clarity	6	60

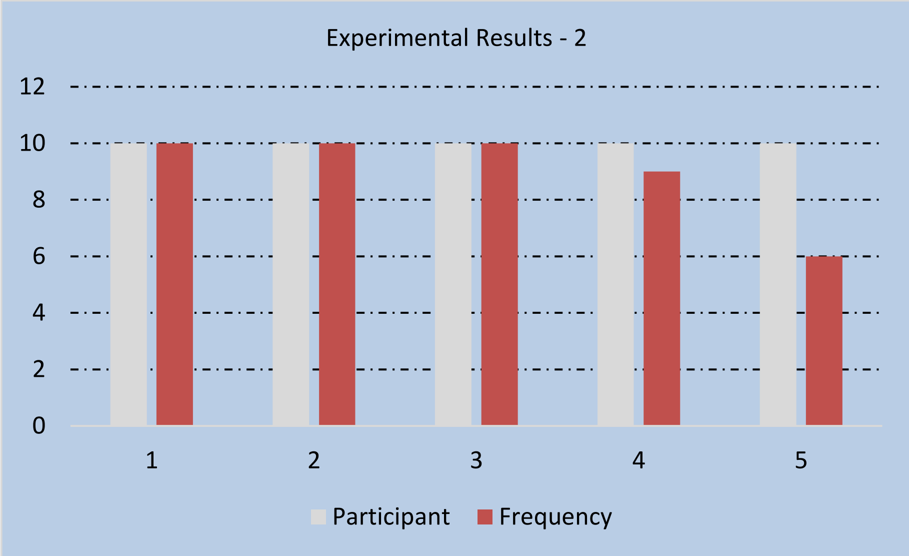

Figure 9. Graphical representation of experimental results - 2.

According to the answers to the question 2, the main themes were categorized as the physical and cognitive suitability of the robot. When the results obtained from the suitability table are examined, it is concluded that the prepared material achieved an average of 90% success in these themes. It is an important feature that the coding education robot has an interesting and intriguing design as it is supported by moving-sound-light stimuli. This feature encourages preschool children to use this material. It is obvious that the coding education is regarding an enjoyable educational environment. Furthermore, the materials used are suitable for health and safety. In education, the tasks that are requested from the child to be achieved are in accordance with the cognitive level of the age group. But the view that it is complex for the children to be able to plan the movement of the mobile robot on the playground, and create this movement on another platform, the magne-board, is stated. The themes that include the preschool teachers' and academicians' views on the coding education material's contributions to students are presented in Table 3 under development and creativity. In addition, graphical representation of experiment results also is given in Figure 10.

Table 3. The contributions of learning coding for the student.

Theme	Sub-themes	f	%
Revenue	1. Success, happiness and increase in self-confidence	7	70
	2. Contribution to the lessons that they will take in the future	6	60
Creativity	3 Application development, production	5	50
	4. Mental development, producing an idea	9	90
	5. Supra-cognitive awareness	7	70

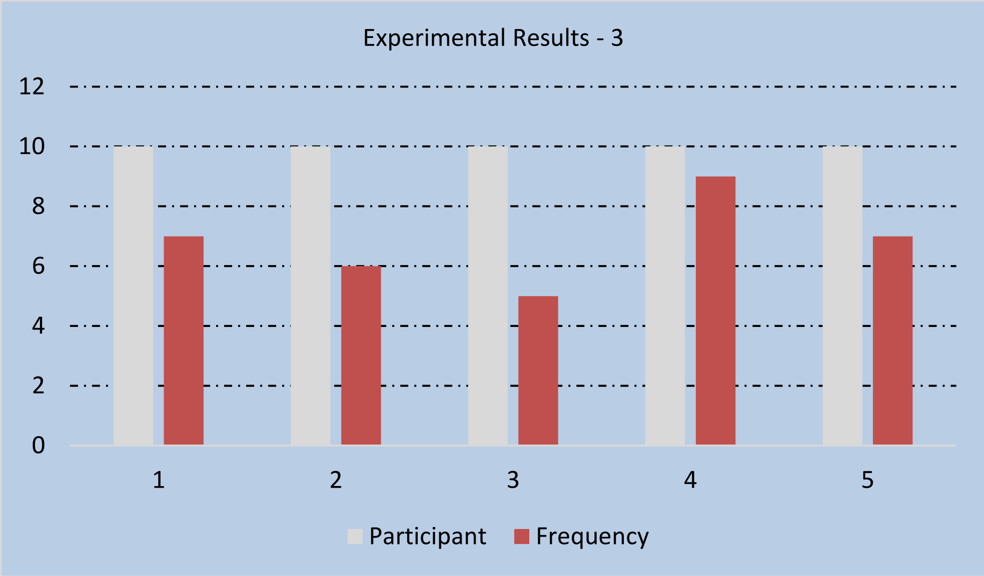

Figure 10. Graphical representation of experimental results - 3.

According to the answers to the question 3, it makes a positive contribution to their seeing the results by concreting the steps of solution that children visualized in their minds and to the increase of their self-confidence. They will be able to transfer this education to the solutions of the issues that they encounter in daily life and of the problems that they will see in the lessons of natural sciences and mathematics that they will take in the following years. The different applications that they will realize with the education robot will make a positive contribution to their mental development and create a supra-cognitive awareness. When the results obtained from the positive contribution table are examined, it is concluded that the prepared material achieved an average of 70% success in the given themes.

Finally, their recommendations were asked to the preschool teachers and specialist academicians about the development of the coding education robot. They made a criticism that the education robot's magne-board could have a more understandable design. Together with that, another view was that the children could get bored of the current themes of educational environment. It was stated that an education robot, which has changeable and different themes, could increase the robot's usage time, and keep children's interest alive. In the next step of the study, it is planned to make a more detailed study in which the afore mentioned measurements will be added. Thus, it is thought that the success rates of some sub-themes with a low success rate will increase.

5. Conclusions and Recommendations

In this study, an educational robot was designed to provide coding education to preschool children. The physical properties of this robot are created in bright colors, shapes and sizes that can attract the attention of preschool children who are the target audience. In addition, it is supported by audible and luminous stimuli. In this way, a fun educational environment is planned. While designing this educational material which consist of 3 main part, it is aimed to give the concept of computational thinking for children. In accordance with this concept, a problem is created for the child with this educational robot and then he/she is asked to plan the steps to solve this problem step by step. The child visualizes the solution in his/her mind and solves the problem with the right moves.

The educational robot was made available to a total of 40 children aged 4 and 5. Children's interaction with the robot was observed by preschool teachers and academicians consisting of 10 people in total. According to the answers to the questions posed to the observers, the designed material was evaluated. The findings were categorized and scored as sub-themes and main themes. According to the findings, most of the observers think that the education robot is useful for creating awareness, developing imagination, creating a sense of success, and fulfilling a social responsibility. In addition, the physical properties of the robot and the comprehension level of the education were appropriate to the cognitive level of pre-school children. It was expressed by observers that this experience makes children happy, increases their self-confidence and supports their creativity. It is stated that the gains can be used by students to solve problems in other courses. Based on these opinions, the coding education robot is thought to be an educational material that can be used to introduce preschool children to coding.

In the literature, there are many education materials that were developed for the same purpose. The coding education robot that was created in this study was also an alternative study, which was prepared with cost efficiency (about 35€) and whose effectiveness was explained with the performed measurements. The materials used in mechanical and electronic components are very affordable and durable. Because it has a simple design, it can be easily changed by any adult if any material change is needed. The coding education robot designed in this study is an effective and easily accessible education material that can be used by any school or family.

References

Alimisis, D., Moro, M., & Menegatti, E. (2017). The use of robotics in introductory programming for elementary students. In *Educational Robotics in the Makers Era* (Vol. 560).

Barnes, J., Fakhrhosseini, S. M., Vasey, E., Park, C. H., & Jeon, M. (2020). Child-Robot Theater: Engaging Elementary Students in Informal STEAM Education Using Robots. *IEEE Pervasive Computing*, *19*(1), 22–31.

Barr, V., & Stephenson, C. (2011). What is the Role What is Involved Science Education of the Computer Community? *Acm Inroads*, *2*(1), 48–54.

Barron, B., Cayton-Hodges, G., Copple, C., Darling-Hammond, L., Levine, M. H., & Bofferding, L. (2011). Take a giant step: A blueprint for teaching young children in a digital age. In *The Joan Ganz Cooney Center at Sesame Workshop and Stanford University* (Vol. 16, Issue 11).

Bers, Marina U, Ponte, I., Juelich, K., & Schenker, J. (2002). Teachers as designers: Integrating robotics in early childhood education. *Information Technology in Childhood Education Annual*, 123–145.

Bers, Marina Umaschi. (2008). Blocks to Robots: Learning with Technology in the Early Childhood Classroom. In *Journal of Chemical Information and Modeling*. Teacher's College Press.

Bers, Marina Umaschi, Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers and Education*, *72*, 145–157.

Brosterman, N. (1997). *Inventing kindergarten*. H. N. Abrams.

Cejka, E., Rogers, C., & Portsmore, M. (2006). Kindergarten robotics: Using robotics to motivate math, science, and engineering literacy in elementary school. *International Journal of Engineering Education*, *22*(4), 711–722.

Chu, J., Zhao, G., Li, Y., Fu, Z., Zhu, W., & Song, L. (2019). Design and Implementation of Education Companion Robot for Primary Education. *2019 IEEE 5th International Conference on Computer and Communications Eftjho*, 1327–1331.

Conway, M., Paasch, R., Gossweiler, R., & Burnette, T. (1994). Alice: A rapid prototyping system for building virtual environments. *Conference on Human Factors in Computing Systems - Proceedings*, *1994-April*, 295–296.

Dwyer, D. C., Ringstaff, C., & Sandholtz, J. H. (1991). Changes in Teachers' Beliefs and Practices in Technology-Rich Classrooms. *Educational Leadership*, *48*(8), 45–52.

Gelman, R., & Brenneman, K. (2004). Science learning pathways for young children. *Early Childhood Research Quarterly*, *19*(1), 150–158.

Gültepe, A. (2018). Kodlama Öğretimi Yapan Bilişim Teknolojileri Öğretmenleri Gözüyle Öğrenciler Kodluyor. *Uluslararası Liderlik Eğitimi Dergisi*, *2*(2), 50–60.

Ishii, H., & Ullmer, B. (1997). *Tangible bits*. 234–241.

Jeschke, S., Kato, A., & Knipping, L. (2008). The Engineers of Tomorrow Teaching Robotics to Primary School Children. *Proceedings of SEFI Annual Conference*, 1–4.

Kahn, K. (1999). A Computer Game to Teach Programming Introduction to ToonTalk. *Proceedings of the National Educational Computing Conference*, *July 2001*, 127–135.

Karim, M. E., Lemaignan, S., & Mondada, F. (2015). A review: Can robots reshape K-12 STEM education? *Proceedings of IEEE Workshop on Advanced Robotics and Its Social Impacts, ARSO*, 1–8.

Kelleher, C., & Pausch, R. (2005). Lowering the Barriers to Programming: A Taxonomy of Programming Environments and Languages for Novice Programmers. *ACM Computing Surveys*, *37*(2), 83–137.

Lee, I., Martin, F., Denner, J., Coulter, B., Allan, W., Erickson, J., Malyn-Smith, J., & Werner, L. (2011). Computational thinking for youth in practice. *ACM Inroads*, *2*(1), 32–37.

Lee, K. T. H., Sullivan, A., & Bers, M. U. (2013). Collaboration by Design: Using Robotics to Foster Social Interaction in Kindergarten. *Computers in the Schools*, *30*(3), 271–281.

Ortega, R., Romera, E. M., & Monks, C. P. (2009). The impact of group activities on social relations in an early education setting in Spain. *European Early Childhood Education Research Journal*, *17*(3), 343–361.

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas*. Basic Books.

Perlman, R. (1976). Using Computer Technology to Provide a Creative Learning Environment for Preschool Children. In *MIT Logo Memo 24*.

Portsmore, M. (1999). ROBOLAB: Intuitive Robotic Programming Software to Support Life Long Learning. *APPLE Learning Technology Review*, *Spring/Summer*, 26–39.

Resnick, M. (2007). Sowing the Seeds for a More Creative Society. *Learning & Leading with Technology*, *35*(4), 18–22.

Resnick, M., Martin, F., Berg, R., Borovoy, R., Colella, V., Kramer, K., & Silverman, B. (1998). Digital manipulatives: New toys to think with. *Conference on Human Factors in Computing Systems - Proceedings*, *April*, 281–287.

Sapounidis, T., & Demetriadis, S. (2011). Touch your program with hands: Qualities in tangible programming tools for novice. *Proceedings - 2011 Panhellenic Conference on Informatics, PCI 2011*, 363–367.

Sapounidis, T., & Demetriadis, S. (2013). Tangible versus graphical user interfaces for robot programming: Exploring cross-age children's preferences. *Personal and Ubiquitous Computing*, *17*(8), 1775–1786.

Schneider, B., Jermann, P., Zufferey, G., & Dillenbourg, P. (2011). Benefits of a tangible interface for collaborative learning and interaction. *IEEE Transactions on Learning Technologies*, *4*(3), 222–232.

Smith, A. C. (2007). Using Magnets in Physical Blocks That Behave As Programming Objects. *Proceedings of the 1st International Conference on Tangible and Embedded Interaction*, 147–150.

Sullivan, A., & Bers, M. U. (2016). Robotics in the early childhood classroom: learning outcomes from an 8-week robotics curriculum in pre-kindergarten through second grade. *International Journal of Technology and Design Education*, *26*(1), 3–20.

Sullivan, A., R. Kazakoff, E., & Umashi Bers, M. (2013). The Wheels on the Bot go Round and Round: Robotics Curriculum in Pre-Kindergarten. *Journal of Information Technology Education: Innovations in Practice*, *12*, 203–219.

Wing, J. M. (2006). Computational Thinking. *Communications of the ACM*, *49*(3), 33–35.

Wyeth, P. (2008). How young children learn to program with sensor, action, and logic blocks. *Journal of the Learning Sciences*, *17*(4), 517–550.

Yu, J., & Roque, R. (2018). A Survey of Computational Kits for Young Children. *Proceedings of the 17th ACM Conference on Interaction Design and Children*, 289–299.