EĞİTİMDE YENİ YAKLAŞIMLAR DERGİSİ
Journal of New Approaches in Education

Cilt 6/Sayı 2, 2023, s. 123-134

Makale Bilgisi/ArticleInfo
Geliş/Received: 27.09.2023 *Kabul/Accepted: 30.12.2023*

ROBOTİK KODLAMA EĞİTİMİNDE ARTIRILMIŞ GERÇEKLİK TABANLI MATERYAL TASARIMI VE UYGULAMASI

Çağatay Ersin[1] - Mehmet Güneş[2]

ÖZET

Gelişen teknoloji ile birlikte robotik kodlama eğitimi önemini giderek artırmıştır. Robotik kodlama ile öğrenciler problem çözme ve mantıksal düşünme becerilerini geliştirmektedir. Yapılan bu çalışmada ilköğretim öğrencilerinin robotik kodlama eğitimlerini gerçekleştirebileceklerine olanak tanıyan ahşap tabanlı bir materyal geliştirilmiştir. Bu materyal ile soyut ve bilişsel olarak anlaşılması zor olan robotik kodlama eğitimindeki soyut kavramları görselleştirerek öğrenmenin kolaylaştırılması amaçlanmıştır. Çalışmada ekolojik, yenilenebilir ve sürdürülebilir bir malzeme olan huş ağacından üretilmiş ahşap kontrplak kullanılmıştır. Robotik kodlama eğitiminde kullanılan kod blokları bu malzeme ile görsel olarak oluşturulmuştur. Daha sonra 5 farklı robotik uygulama belirlenmiş ve Scratch programındaki kod blokları puzzle olarak birleştirilmiştir. Her bir uygulama mikrodenetleyici geliştirme kartı ve elektronik malzemeler ile gerçekleştirilmiştir. Tasarımı yapılan kod blokları ve uygulamaların çalışma görselleri artırılırmış gerçeklik uygulamasına entegre edilmiştir. Öğrenciler uygulamaları kod blokları ile bilgisayar olmayan ortamda Scratch blok olarak tasarlanan materyal kutusu içerisinde yapacaktır. AR (Artırılırmış gerçeklik) mobil uygulaması kod blokları üstüne getirildiğinde, kod blokları doğruysa uygulamanın görseline ulaşılacaktır. Bu çalışma robotik kodlama eğitimini somutlaştırarak oyun tabanlı öğrenmeye olanak sağlayacaktır.

Anahtar Kelimeler: Artırılmış gerçeklik, malzeme tasarımı, Scratch kodlama, QR kod.

DESIGN AND APPLICATION OF AUGMENTED REALITY-BASED MATERIAL IN ROBOTIC CODING EDUCATION

ABSTRACT

With the advent of advancing technology, the importance of robotic coding education has increasingly gained prominence. Robotic coding enables students to enhance their problem-solving and logical thinking skills. In this study, a wood-based material has been developed to facilitate elementary school students in undertaking robotic coding education. This material aims to simplify learning by visualizing abstract concepts that are cognitively challenging to grasp in robotic coding education. Ecological, renewable, and sustainable materials, specifically birch plywood, have been utilized in the study. The code blocks used in robotic coding education have been visually created using this material. Subsequently, five different robotic applications were identified, and the code blocks in the Scratch program were assembled like a puzzle. Each application was executed using a microcontroller development board and electronic components. The designed code blocks and the visuals of the applications have been integrated into an augmented reality application. Students will perform the applications within a material box designed as Scratch blocks in a non-computer environment. When the AR (Augmented Reality) mobile application is placed over the code blocks, if the blocks are correct, visuals of the application will be displayed. This study will concretize robotic coding education, thus enabling game-based learning.

Keywords: Augmented reality, material design, Scratch coding, QR code.

[1] Lec. Dr, Çankırı Karatekin University Vocational, cagatayersin@karatekin.edu.tr
[2] Lec. Dr, Çankırı Karatekin University Vocational, mehmetgunes@karatekin.edu.tr

1. INTRODUCTION

Contemporary technology offers myriad opportunities to enrich learning experiences and augment students' learning motivation and performance in education. Augmented Reality (AR) is applicable for learning, entertainment, or education by enhancing the user's perception and interaction with the real world. The user can move around the three-dimensional virtual image and view it from any perspective, much like a real object (Kesim & Özarslan, 2012). AR is a technology that provides visual and auditory experiences to users by integrating computer-generated virtual objects with the real world (Azuma, 1997). This technology allows users to experience the real world in a more enriched and interactive manner. AR combines a suite of technologies to perceive the real world, position virtual objects, and enable users to interact with these objects (Milgram & Kishino, 1994). Although AR technology is used in areas such as entertainment, health, tourism and the military, its use is also increasing in the field of education (Akgün & Üstün, 2023). With a broad range of applications, AR technologies have recently started to find a place in the educational sector as well (Fleck, Hachet, & Bastien, 2015). AR encourages students to effectively use multiple sensory organs, expanding their perspectives and potentially increasing their interest and curiosity (Yen, Tsai, & Wu, 2013). The integration of AR into the teaching and learning environment can enhance students' interest in course materials. This, in turn, promotes more active participation in the learning process while also providing opportunities for experiential and applied learning (Taşkıran, Koral & Bozkurt, 2015). AR used in education merges the real world with virtual elements, creating rich content that targets multiple sensory organs (Özarslan, 2013). Active participation and the fun factor in students' learning processes stimulate effective learning. The use of AR applications further strengthens the student's interaction with reality (İbili & Şahin, 2013).

Given this context, AR technology and material design have been increasingly being used in education in recent years (Wu, Lee, Chang & Liang, 2013). AR is a technology that allows the merging of the real world with virtual objects and is used to visually enrich learning materials. Updating education and integrating new technologies such as augmented reality can help students learn more effectively and develop their creativity (Ozaltun & Karaman, 2023). Material design, on the other hand, is implemented to enrich learning materials visually, audibly, and tactilely. The use of AR and material design in education has the potential to enrich students' learning experiences, thereby increasing their learning motivation and success. Specifically, in technology-focused education, the use of AR and material design can help students improve their skills in coding, robotics, engineering, and other technology fields (Klopfer & Squire, 2008). However, the implementation of this technology can encounter some challenges, such as students' readiness and affinity towards these technologies being insufficient (Akçayır & Akçayır, 2017; Sadi & Şekerci, 2008). Research has shown that the use of AR applications in education has a positive impact on student success and self-efficacy perception (Sirakaya & Çakmak, 2018). Studies on the use of material design in education indicate that technology can enhance students' learning experiences. Digital game-based learning increases student motivation and learning effectiveness while providing deeper learning without adversely affecting motivation (Erhel & Jamet, 2013). The availability of packaged software that allows the development of AR applications without the need for coding increases educators' interest in AR technology (İçten & Bal, 2017). A series of advantages offered by AR technology in education have been identified through various studies. Some of these advantages include: AR technology contributes to the development of students' creativity and imagination while increasing their interactions and perceptions of the real world, making them more enthusiastic about the learning process.

- It carries the potential to create a unique learning environment catering to various learning styles.
- The integration of real and virtual objects helps the student focus more on the activity.
- Real-time interaction increases student-content interaction (Wojciechowski & Cellary, 2013).
- The use of AR facilitates the concretization of abstract concepts, thereby making it easier for students to understand.
- Being a new technology, it sparks interest and curiosity in students, thereby encouraging learning through fun.
- Teaching with AR technology simplifies the understanding of topics that are difficult to learn and teach.
- Environments and interactions that cannot be created in the real world become possible through AR (Tami & Rambli, 2013; Kerawalla, Luckin, Seljeflot & Woolard, 2006).

Both augmented virtual reality and robotic coding education have significant potential in terms of expanding learning opportunities. Both individually contribute to enhancing students' STEM (Science, Technology, Engineering, Mathematics) skills, and when combined, offer a more comprehensive learning experience. These educational methods simulate situations that students may encounter in real life, thereby facilitating more effective learning (Colak, Irmak, Kabalci, & Issi, 2014). In the future, augmented virtual reality and robotic coding education will contribute to the success of students in a technological world. In addition, when studies are examined, it is seen that the achievements of students using AR learning materials are positively affected (Gül & Şahin, 2017). Programming education for primary school students serves as a pivotal opportunity for skill development within technology-focused curricula. The integration of Augmented Reality (AR) and material design methodologies can potentially enhance the coding learning experience for these students, making it more effective and engaging. Thus, as research on the use of AR and material design in coding education expands, educators are expected to enrich and facilitate the student's learning experiences through these technologies (Demirer & Sak, 2016). In the researched literature, it was observed that robotic studies were carried out with code blocks related to robotic coding education. These applications were made with computer-aided or augmented reality applications. In this study, robotic applications were carried out with wooden code blocks by running the AR application with any Android operating system mobile device without using a computer. This paper aims to augment learning activities in primary school coding education through the incorporation of AR and sustainable material design. To that end, educational materials have been crafted using eco-friendly wooden materials and water-based acrylic paints. Subsequent sections offer recommendations on the implementation of AR and material design in coding education.

2. MATERIALS AND METHODS

Contemporary coding education has extended to block-based coding platforms for grades 1 through 4 and even pre-school levels. Block-based coding allows primary students to create animations and games by dragging and dropping puzzle-like visual elements, referred to as 'code blocks', in a computerized environment, thereby making coding education accessible and fun. With the increasing prevalence of block-based coding, research is being conducted on coding kits utilized in elementary and middle school settings. Several educational software applications operate on block-based coding logic, including but not limited to Scratch, Kodu Game Lab, Code.org, M-Block, S4A, and AppInventor. Given the technological era we inhabit, coding education has evolved from a hobby to a necessity. Consequently, research in this area is on the rise, and one of the key outcomes of coding education is the enhancement of creative thinking skills (Haymana & Özalp, 2020). Moreover, studies indicate that robotic coding applications positively impact computational thinking abilities (Karataş, 2021). In the present study, robotic coding educational materials have been created for primary school students using wooden code blocks and puzzle visuals. Five basic robotic applications were selected and integrated with an AR application.

2.1. Creating Code Block

Vector-based code blocks were designed using CAD software, and wooden plywood materials were prepared for these blocks. These materials were then laser-cut using a CO_2 machine, as depicted in Figure 1 and were made ready for coloring. The raw puzzle blocks were painted in various colors using non-toxic EN-71 standard acrylic paints. Once the painting process was completed, the blocks were returned to the laser cutting machine, as seen in Figure 2, for the engraving of necessary texts and numbers onto the wooden blocks.

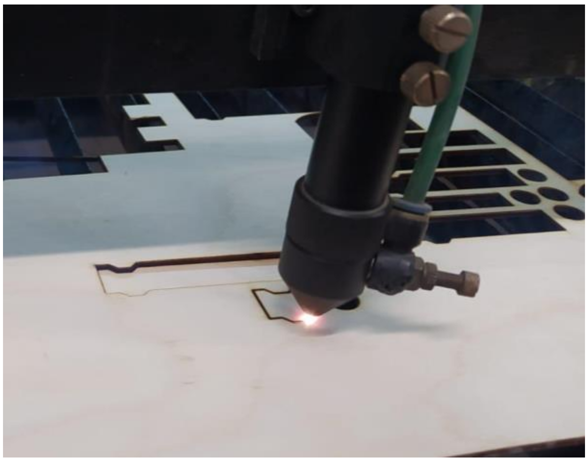


Figure 1. Laser Cutting Process

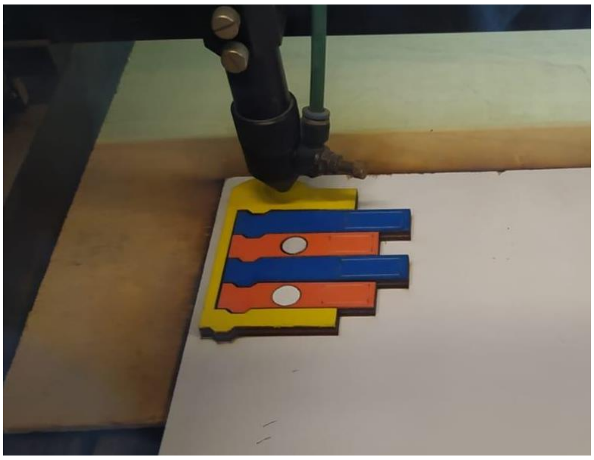


Figure 2. Text and Shape Engraving Process

The produced code blocks are classified according to their colors as follows.

Blue Blocks: Output

Yellow Blocks: Control

Orange Blocks: Delay

Green Blocks: Mathematics

White Blocks: Numerical Values

Purple and Magenta: Input

After the wooden puzzle blocks were created, storage boxes were manufactured to facilitate the student's application process by allowing for organized storage and arrangement of the blocks.

2.2. Implementation of the AR Application

Learning computer programming plays a significant role beyond coding; it contributes to students' acquisition of skills such as problem-solving, collaborative learning, creative thinking, and critical thinking (Çatlak, Tekdal & Fatih, 2015). Scratch is a block-based graphical programming language developed by a team at the Massachusetts Institute of Technology (MIT) Media Lab, designed for learners aged 8-16. It enables learners to create their designs, express themselves in various ways, and acquire 21st-century skills without the need for syntax-based code writing. Users can effortlessly drag and drop blocks from pre-existing code packages on the project screen, thereby eliminating syntax errors and offering considerable ease of use. Projects can be shared online as open-source code, and the platform supports over 40 languages, facilitating global user communication and collaborative project development (Kışla, Yıldız & Çobanoğlu, 2019). The study introduced a wooden material composed of coding blocks for students who do not have the necessary hardware to use the Scratch computer and software program. This material was produced from birch plywood. The coding blocks were created on a laser cutting machine for five different basic robotic applications (LED activation, motion detection via PIR sensor, LED control via button, LED activation via LDR light sensor, and servo motor operation). These blocks, manufactured following the logic of a puzzle, are combined to form the code required for the application. The assembled coding blocks are shown in Figure 3.

Figure 3. Coding blocks made from wooden materials

In environments where a computer is not available, users can engage in robotic coding activities using the coding blocks produced, following the logic of a puzzle. Yellow-coded blocks represent decision blocks, green-coded blocks are comparison operators, blue-coded blocks are output blocks, and orange-coded blocks are wait blocks. An example code design for activating an LED is shown in Figure 4.

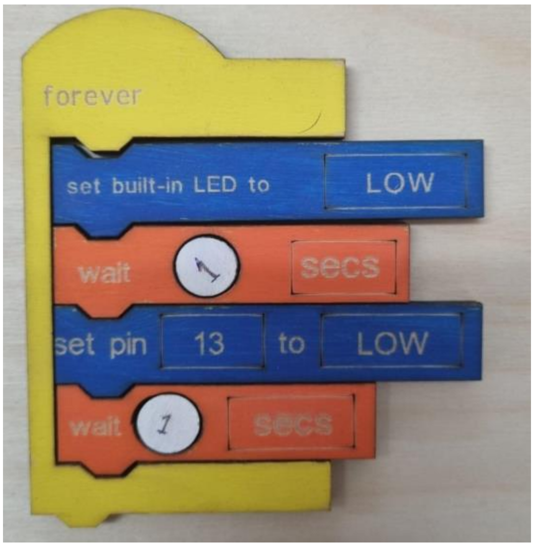


Figure 4. Executed example code block (LED activation)

Visuals for five different robotic applications created with coding blocks are shown in the Scratch interface in Figure 5.

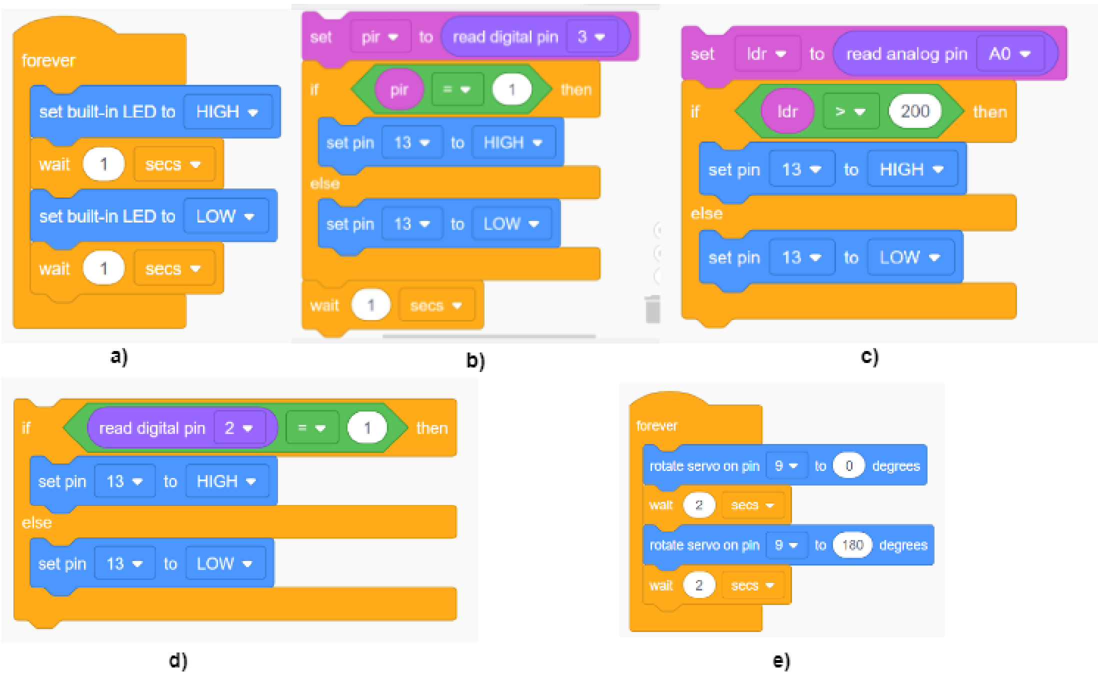
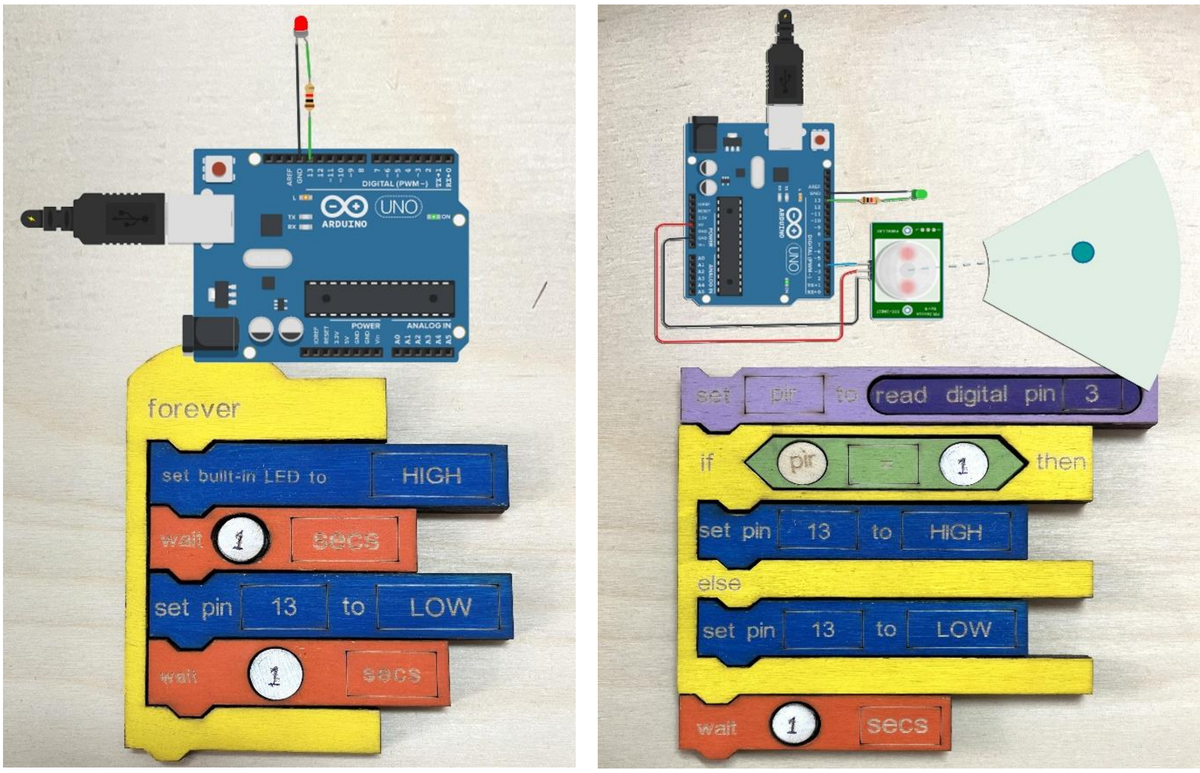


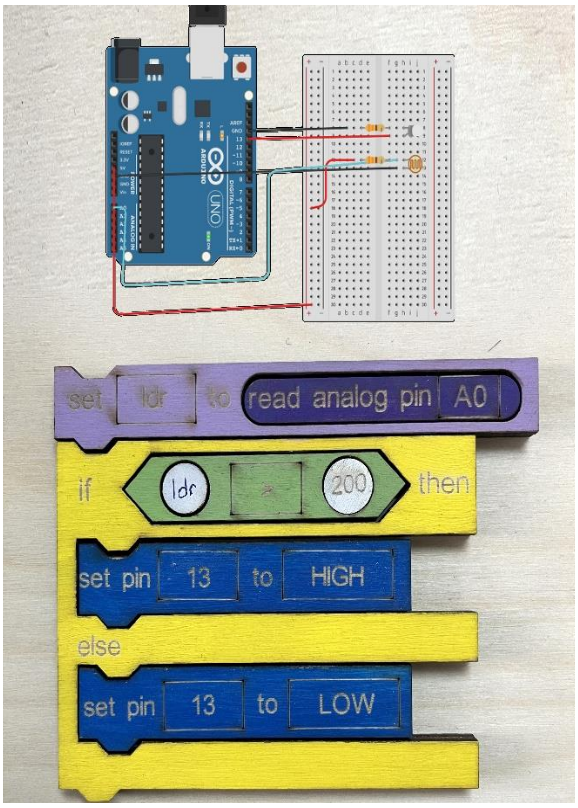
Figure 5. Code blocks used in the application (a) LED activation, b) Motion-sensitive LED activation with PIR sensor, c) LED activation with LDR light sensor, d) LED activation with a button, e) Operating a servo motor

In this study, the created coding blocks are visualized using the augmented reality application, MS AR. When the user correctly combines the coding blocks and shows them to the application, a visual video of that coding block will play in the augmented reality application. For example, if the user assembles the 'operate servo motor' code, they will observe in the application that the servo motor operates between 0-180 degrees. With this work, children in environments without a computer can perform robotic coding applications with natural wooden coding blocks.

The code blocks created in this study were visualized with the augmented reality application MS Augmented reality application. When the user combines the code blocks correctly and shows them to the application, the visual video of that code block will work in the Augmented Reality application. For example, when the user combines the servo motor start code, he will observe that the servo motor works 0-180 degrees in the application. With this study, children will be able to make robotic coding applications with natural wooden code blocks in a non-computer environment. Visuals of the five applications are shown in Figure 6.

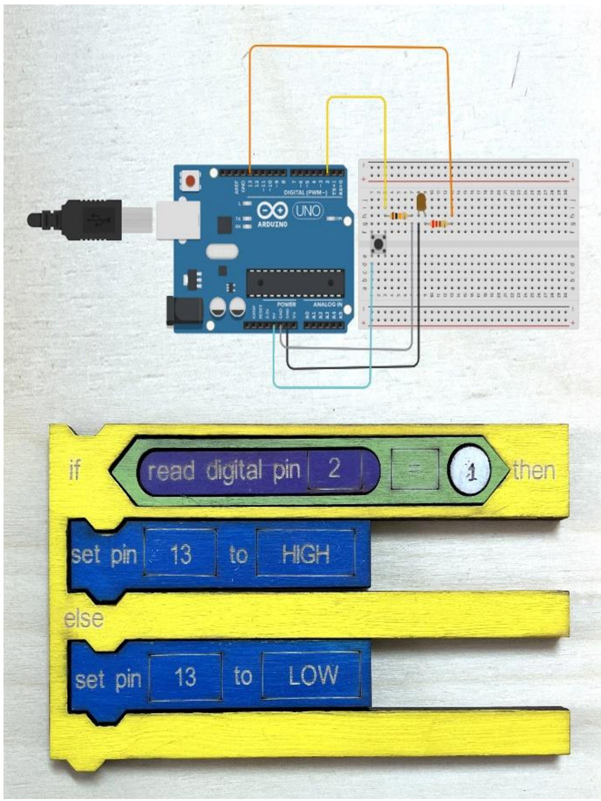


a) **b)**



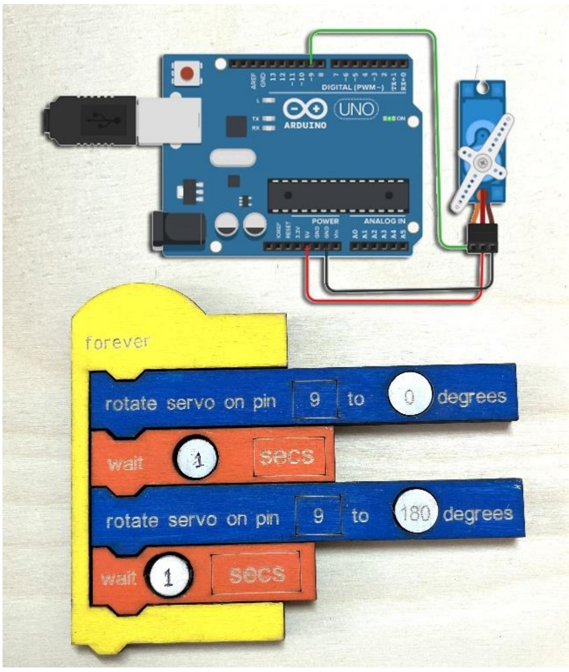
set
ldr
to
read analog pin
A0
if
ldr
200
then
set pin
13
to
HIGH
else
set pin
13
to
LOW

c)



if
read digital pin
2
1
then
set pin
13
to
HIGH
else
set pin
13
to
LOW

d)



forever
rotate servo on pin
9
to
0
degrees
wait
1
secs
rotate servo on pin
9
to
180
degrees
wait
1
secs

e)

Figure 6. LED lighting with augmented reality application a) LED activation, b) Motion-sensitive LED activation with PIR sensor, c) LED activation with LDR light sensor, d) LED activation with a button, e) Operating a servo motor

3. CONCLUSION

Nowadays, the use of augmented reality applications is becoming increasingly widespread, and they make significant contributions, especially to education and material studies. In this study, robotic coding training materials were designed using natural birch wood materials. For the design, coding blocks for 5 different applications were created and painted with acrylic paint, which is a safe material for users. The operation of code blocks is visually represented as an application. The application of the code blocks was made in the Tinkercad online 3D modelling program. Once the user has correctly assembled the blocks of code, they can run it from an Android device using the augmented reality application (Augment mobile) and the visual representation of the robotic application will appear on the screen. If the user combines code blocks incorrectly, a 'code not working' warning will be given. With this study, users will learn Scratch coding in a computer-free environment using natural wooden coding blocks put together with puzzle logic. For future studies, it is recommended to increase the number of applications and structure them gradually.

Competing Interests

The authors declare that they have no competing interests.

REFERENCES

Akgün, E., & Üstün, A. B. (2023). Mobil artırılmış gerçeklikle öğrenmeye yönelik içerik analizi. *Dokuz Eylül Üniversitesi Buca Eğitim Fakültesi Dergisi*, 56, 362-383.

Azuma, R. T. (1997). A survey of augmented reality. *Presence: teleoperators and virtual environments*, 6 (4), 355-385.

Colak, I., Irmak, E., Kabalci, E., & Issi, F. (2014). Design and implementation of a remote laboratory platform using MATLAB builder for NE. *Computer Applications in Engineering Education*, 22, 617-629.

Çatlak, Ş., Tekdal, M., & Baz, F. (2015). Scratch yazılımı ile programlama öğretiminin durumu: Bir doküman inceleme çalışması. *Journal of Instructional Technologies and Teacher Education*, 4 (3), 13-25.

Demirer, V., & Nurcan, S. A. K. (2016). Programming education and new approaches around the world and in Turkey/Dünyada ve Türkiye'de programlama eğitimi ve yeni yaklaşımlar. *Eğitimde Kuram ve Uygulama*, 12 (3), 521-546.

Erhel, S., & Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers and Education*, 67, 156-167.

Fleck, S., Hachet, M., & Bastien, J. C. (2015). Marker-based augmented reality: Instructional-design to improve children interactions with astronomical concepts. *Proceedings of the 14th International Conference on Interaction Design and Children*, 21-28.

Haymana, İ., & Özalp, D. (2020). Robotik ve kodlama eğitiminin ilkokul 4. sınıf öğrencilerinin yaratıcı düşünme becerilerine etkisi. *İstanbul Aydın Üniversitesi Eğitim Fakültesi Dergisi*, 6 (2), 247-274.

İbili, E., & Şahin, S. (2013). Software design and development of an interactive 3D geometry book using augmented reality: ARGE3D. *Afyon Kocatepe University Journal of Science and Engineering*, 13 (1), 1-8.

İçten, T., & Bal, G. (2017). Artırılmış gerçeklik teknolojisi üzerine yapılan akademik çalışmaların içerik analizi. *Bilişim Teknolojileri Dergisi*, 10 (4), 401-415.

Gül, K., & Şahin, S. (2017). Bilgisayar donanım öğretimi için artırılmış gerçeklik materyalinin geliştirilmesi ve etkililiğinin incelenmesi. *Bilişim Teknolojileri Dergisi*, 10 (4), 353-362.

Karataş, H. (2021). 21. yy. Becerilerinden robotik ve kodlama eğitiminin türkiye ve dünyadaki yeri. *21. Yüzyılda Eğitim ve Toplum Eğitim Bilimleri ve Sosyal Araştırmalar Dergisi*, 10 (30), 693-729.

Kerawalla, L., Luckin, R.., Seljeflot, S., & Woolard, A. (2006). "Making it real": exploring the potential of augmented reality for teaching primary school science. *Virtual Reality*, 10, 163-174.

Kesim, M., & Ozarslan. Y. (2012). Augmented reality in education: current technologies and the potential for education. *Procedia-Social and Behavioral Sciences*, 47, 297-302.

Kışla, T., Yıldız, Ş. N., & Çobanoğlu, A. A. (2019). Bilişim Teknolojileri Öğretmenlerine Yönelik Scratch Bilgi Paylaşım Platformunun (Sbpp) Geliştirilmesi. *Uluslararası Eğitim Bilim ve Teknoloji Dergisi*, 5 (1), 37-50.

Klopfer, E., & Squire, K. (2008). Environmental Detectives-the development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development*, 56, 203-228.

Milgram, P., & Kishino, F. A. (1994). Taxonomy of mixed reality visual displays. *IEICE Transactıons on Information and Systems*, 77 (12), 1321-1329.

Özaltun, G., & Kahraman, M. E. (2023). Artırılmış gerçeklik (AG) teknolojisinin tasarım eğitiminde etkileşimli öğrenmeye katkısı. *Art-E Sanat Dergisi*, 16 (32), 669-700.

Özarslan, Y. (2013). Öğrenme ve öğretmenin genişletilmiş gerçeklik ile zenginleştirilmesi: OptikAR uygulaması. *XV. Akademik Bilişim Konferansı*, 477-480.

Sadi, S., Şekerci, A., Kurban, B., Topu, F., Demirel, T., Tosun, C., & Göktaş, Y. (2008). Öğretmen eğitiminde teknolojinin etkin kullanımı: Öğretim elemanları ve öğretmen adaylarının görüşleri. *Bilişim Teknolojileri Dergisi*, 1 (3), 43-49.

Sirakaya, M., & Cakmak, E. K. (2018). Effects of augmented reality on student achievement and self-efficacy in vocational education and training. *International Journal For Research in Vocational Education and Training,* 5 (1), 1-18.

Taşkıran, A., Koral, E., & Bozkurt, A. (2015). Artırılmış gerçeklik uygulamasının yabancı dil öğretiminde kullanılması. *Akademik Bilişim*, 462-467.

Tomi, A. B., & Rambli, D. R. A. (2013). An interactive mobile augmented reality magical playbook: Learning number with the thirsty crow. *Procedia Computer Science*, 25, 123-130.

Wojciechowski, R., & Cellary, W. (2013). Evaluation of learners' attitude toward learning in ARIES augmented reality environments. *Computers and Education*, 68, 570-585.

Wu, H. K., Lee, S. W. Y., Chang, H. Y., & Liang, J. C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers and Education*, 62, 41-49.

Yen, J. C., Tsai, C. H., & Wu, M. (2013). Augmented reality in the higher education: Students' science concept learning and academic achievement in astronomy. *Procedia-Social and Behavioral Sciences*, 103, 165-173.