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Robotic Technologies in Education and Educational Robotic Applications

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Bu makaleye atıf için (To cite this article):
Çaka, C. (2022). Robotic Technologies in Education and Educational Robotic Applications [Eğitimde Robotik Teknolojiler ve Eğitsel Robotik Uygulamaları]. *Bilim, Eğitim, Sanat ve Teknoloji Dergisi (BEST Dergi) [Science, Education, Art and Technology Journal (SEAT Journal)]*, *6*(2), 179-189.

Makale Türü (Paper Type):
Derleme (Literature Review)

Etik Kurul Adı, Onay Tarihi ve Sayısı (Ethics Committee Name, Approval Date and Number):
Derleme çalışması olduğu için etik kurul onayı gerektirmiyor.

Bilim, Eğitim, Sanat ve Teknoloji Dergisi (BEST Dergi)
Science, Education, Art and Technology Journal (SEAT Journal)
Cilt (Volume) 6, Sayı (Number) 2, 2022, Sayfa (Page) 179-189

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Article Info

Article History

Received:
30 September 2021

Accepted:
28 April 2022

Key Words

Robot
Robotics
Educational robotics

Abstract

Developments in information and communication technologies have triggered a process of social transformation. The spread of technology in every field from past to present has led to emergence of different perspectives on technology. Technological tools are used in almost every field, from medicine to engineering, from education to construction. In this context, robotic technologies have come to the fore as a large developing field that affects human life. When the studies on the use of robotics in education are reviewed, it is seen that developed countries see robotics as a driving force in education and attach great importance to the use of these technologies in terms of improving their education systems. The purpose of the current study designed based on the idea that robotic systems make great contributions to the field of education and will make even more contributions is to investigate robotic technologies and related concepts, the reflections of robotic technologies in the field of education and educational robotic applications. It is thought that such an investigation of the status and reflections of robotic technologies in education and the suggestions presented in this direction will shed light for the studies to be conducted on the use of robotic technologies in education and will provide guidance for researchers.

Eğitimde Robotik Teknolojiler ve Eğitsel Robotik Uygulamaları

Makale Bilgisi

Makale Tarihi

Gönderim Tarihi:
30 Eylül 2021

Kabul Tarihi:

28 Nisan 2022

Anahtar Kelimeler

Robot

Robotik

Eğitsel robotik

Öz

Bilgi ve iletişim teknolojilerinde meydana gelen gelişmeler, toplumsal bir dönüşüm sürecini de beraberinde getirmiştir. Geçmişten günümüze teknolojinin her alanda yaygınlaşması, teknolojiye farklı bakış açıları kazandırmıştır. Tıptan mühendisliğe, inşaat alanında eğitime kadar hemen her alanda teknolojik araçlardan yararlanılmaktadır. Bu çerçevede robotik teknolojiler, insan yaşamını etkileyen ve gelişmekte olan büyük bir alan olarak öne çıkmaktadır. Robotiğin eğitimde kullanımı ile ilgili yapılan çalışmalara bakıldığında gelişmiş ülkelerin robotiği eğitimde itici bir güç olarak gördüğü ve eğitim sistemlerini iyileştirme noktasında bu teknolojilerin kullanımına büyük önem verdiği görülmektedir. Robotik sistemlerin eğitim alanına büyük katkılar sağladığı ve daha da sağlayacağı düşüncesinden yola çıkılarak hazırlanan bu çalışmanın amacı robotik teknolojiler ve ilgili kavramları, robotik teknolojilerin eğitim alanına yansımalarını ve eğitsel robotik uygulamaları irdelemektir. Robotik teknolojilerin eğitimdeki yeri ve yansımalarına ilişkin yapılan bu şekilde bir değerlendirmenin ve bu doğrultuda sunulan önerilerin eğitimde robotik teknolojilerin kullanımına yönelik yapılacak çalışmalara ışık tutacağı ve araştırmacılar için yol gösterici nitelikte olacağı düşünülmektedir.

Introduction

Developments in information and communication technologies have brought about social transformation. In terms of keeping up with this change, 21st century life skills of individuals such as critical thinking, problem solving, creativity and innovation and cooperation have gained greater importance. Gartner (2016) states that in the near future, with the impact of developments in the field of artificial intelligence, the industrial period shaped in the last 200 years will come to an end and the beginning of the individual industrial period will be witnessed and these skills will play a key role in this process. Computational thinking skill, which is involved in all areas of life from science to art, which is expressed by Wing (2006) as a basic skill not only for computer scientists but for everyone and which supports 21st century learner skills, has gained more importance and become widespread parallel to the developing technology. While developments in information and communication technologies greatly facilitate human life, the value attributed to technology is increasing with each day. The fact that technology facilitates daily life with the opportunities it offers has also supported its use in many different areas. Technological tools are used in almost every field from medicine to engineering, from construction to education.

The spread of technology in every field from past to present has led to emergence of different perspectives on technology. When individuals in a society are faced with an innovation, they come to the point of making some decisions about adopting this innovation and about the future of the innovation. This process usually proceeds as follows; the individual develops positive individual responses towards the use of an innovation, creates positive behavioural intentions for its use and then uses the innovation (Rogers, 2003). At this point, there are some factors that directly affect individuals' adoption and use of an innovation. If the individual thinks that the innovation will cause an increase in his/her performance, predicts that it will reduce the physical or mental effort he/she will spend, and believes that he/she will get approval from the people around him/her, he/she will exhibit the behaviour of accepting and using the innovation. In this context, the basic concept addressed in the current study is robotic technologies and, in this connection, robotic technologies and related concepts, reflections of robotic technologies in the field of education and educational robotic applications are examined.

Robotic Technologies

The spread of technology in every field from past to present has led to emergence of different perspectives on technology. Robotic systems are among the most important technologies that carry technology to extreme dimensions and greatly affect human life. The word robot is derived from the Czech word for slave (Horáková & Kelemen, 2003). Today, self-controlling and programmable technological devices consisting of electronic and mechanical parts are called robots. For a machine to be defined as a robot, it must have features to sense sound, colour, light and position and be able to transform what it perceives with these sensors (Aslan, 2014). Robots are products produced by scientists and having three key contents, which are the paradigm of emotion, thought and movement. Robots can be in the form of sensors that detect changes by observing their environment, artificial intelligence that decides how to react to these situations and practitioners who try to create innovations by making changes in today's world. When all these features are possessed, robots can be defined as artificial organisms.

Robots are encountered in different sectors and fields such as military, industry, trade, medicine and space sciences (Strawhacker & Bers, 2015). Robotics, on the other hand, is a concept related to the design of robots in many fields, especially in electronics and engineering, and refers to the operation and use of robots (Koç & Böyük, 2013). Due to the potential of robotic systems to meet user expectations, it is predicted that they will be rapidly adopted both individually and institutionally. Currently, the relatively high cost of robotic systems for individual use leads to widespread use of these technologies on an enterprise scale. There are many types and different usage areas of robotic systems. In light of the literature, it is possible to say that their most common use is in the fields of medicine and engineering. Given the transformative effect of technology in every field, the contribution of robotic systems to the field of education is an undeniable fact. Thus, studies on the use of robotic systems in the field of education have also been carried out (Beran et al., 2011). Robotics-assisted learning refers to the use of robotics as a technology-based learning tool. In the information age we live in, it is expected that individuals and societies can adapt to changing technologies and even produce these technologies to survive. It is important for individuals to have algorithmic thinking skills to produce these technologies. Teaching the algorithm, which is the basis of programming education, to individuals of all ages helps them gain 21st century skills such as computational thinking, creativity and problem solving (Bers, Flannery, Kazakoff, & Sullivan, 2014). On the other hand, there are also negative attitudes towards programming. The main reasons for these attitudes are the perception that programming is extremely difficult (Kazimoglu, Kiernan, Bacon, & Mackinnon, 2012), lack of interest and insufficient incentives (Resnick et al., 2009). However, in the process of eliminating these negative attitudes, with the development of block-based programs and drag-and-drop structures that do not require complex code knowledge, many studies have been conducted on programming education and the use of programming at an early age (Berland & Wilensky, 2015). In addition, it is predicted that in the future, robotic systems will be among the technologies that will be frequently preferred for institutional use as well as for individual use (Gartner, 2019).

Reflections of Robotic Technologies in Education and Educational Robotic Applications

Robots as an educational technology have great potential (Mubin et al., 2013). There are two basic approaches to the use of robots in education. In the first approach, robots and robot-related subjects are the direct objectives of teaching, while in the second approach, robots are used as a teaching tool in teaching subjects such as mathematics, science and technology that are not directly related to robots. Educational robots are sets of robots that learners can use to make programs in an applied manner (Üçgül, 2013). The use of robotic technologies for educational purposes has many contributions in terms of learning process and results. Robotics-assisted learning is used at all educational levels from pre-school to university and supports the process of learning by doing and experiencing through the provision of an environment where learners can design their own products (Alimisis, 2013; Jung & Won, 2018; Mills et al., 2014). Educational robotics is an efficient learning tool and contributes to learners in cognitive and affective terms by creating an enjoyable learning environment that will attract learners' attention (Eguchi, 2015; Kaygısız, Üzümcü & Uçar, 2020). In addition to these contributions, the use of robotic technologies in education supports the process of developing positive attitudes towards the lesson, along with the increase in self-confidence in learners (Bakırcı & Kutlu, 2018; Gültepe, 2018; Khanlari, 2013). During the robot

design process, learners can carry their creativity to real systems (Blikstein, 2013). When robots are used as educational tools, they foster active participation of learners and develop their higher-order thinking skills (Barak & Zadok, 2009; Chalmers, 2018; Chaudhary, Agrawal, Sureka, & Sureka, 2016; Cheng, Huang, & Huang, 2013; Eguchi, 2012; Eteokleous-Grigoriou, & Psomas, 2013; Grandi, Falconi, & Melchiorri, 2014; Socrataus & Ioannou, 2018; Veselovská & Mayerová, 2015). Robot models can be programmed with computers, allowing students to gain higher-order thinking skills as well as critical thinking and computational thinking (Korkmaz, Altun, Usta, & Özkaya, 2014).

Coding is among 21st century skills and has a structure that allows learners to learn by doing and experiencing and contributes to their metacognitive development by providing problem solving opportunities. Coding is creating block-based computer programs using any type of software and developing various algorithms. Parallel to technological developments, coding teaching has also undergone a transformation and the concept of robotic coding has begun to come to the fore. Robotic coding is a type of coding that individuals come up with by combining the science of coding and mechanics. The use of robotic systems in education has brought a new breath to the field of science and technology worldwide. Twenty first century teachers are expected to undertake the task of making learning environments effective and to be open to change and development. Integrated disciplines are important in seeing the practical benefit of theoretical courses. In the 21st century, a single math application or science education may be insufficient. In this context, STEM [Science, Technology, Engineering, Math] education, which aims to bring an interdisciplinary understanding to learning environments, gains importance. Teachers who are sensitive to different disciplines and have a supportive role in the interdisciplinary education of students are an important element in STEM education for information to be processed in a meaningful way (León, Núñez, & Liew, 2015). Robotic systems are among the most preferred technologies in STEM education. The integration of robotic systems into educational environments has the potential to offer students different experimental learning opportunities and supports the process of learning by doing and experiencing. Software programs such as Scratch, Arduino, and robot kits such as mBot, Lego Mindstorms are very common in the teaching of robotic coding. These robotic systems are fun, creativity-enhancing systems that can be used to improve students' design, creation, and programming skills (Gerecke & Wagner, 2007; Lin et al., 2009). The effectiveness of these technologies, which have started to be used in education and are increasing rapidly, in STEM fields are among the important research topics (Sullivan & Bers, 2016). The use of robotic systems in education helps students to improve their experience, academic achievement, motivation, positive attitudes and creative thinking skills (Barker & Ansorge, 2007; Wei, Hung, Lee, & Chen, 2011). To increase the quality of education organized in STEM fields with programming-based robotic activities, the idea of starting programming education at an early age and ensuring the continuity of this education in older ages has come to the fore in recent years.

Visual programming languages like Scratch allow students to program their own programs, develop games and animations without having to learn the complex code structures of traditional programming languages (Resnick et al., 2009). Scratch has been developed by using the drag and drop method with the logic of children playing creatively with lego blocks. All areas such as the coding section of Scratch, the section where the code blocks are

located, and the scene are compared with the environment in which the student displays his/her creativity and quickly lead to the conclusion as if he/she were working on a real desktop (Resnick et al., 2009). Çatlak, Tekdal, and Baz (2015) conducted a literature review through document analysis to examine current studies on the use of Scratch in the teaching of programming. According to the findings of this study, Scratch is effective in the teaching of programming and makes the teaching of programming more enjoyable and understandable. Among the reasons for this situation is the user-friendly interface that does not require coding knowledge and the simple use of code blocks with drag and drop method instead of coding. Studies have revealed that block-based programs perform most of the tasks involving algorithms and programming concepts especially for younger students (Strawhacker & Bers, 2015).

In addition, the programmable Lego robot kits produced by Lego company had positive effects on students' acquiring problem solving and higher-order cognitive skills. Lego robotics can be coded with software by using block-based visual code blocks. Lego robotics is a tool that has been widely used in recent years with its ability to use concrete objects, to show algorithms and programming logic with computer-based software (Danahy et al., 2014; Uçgül, 2013). Lego robotic applications have an important function in involving students in the learning process, contributing to the development of skills such as analytical thinking, finding errors in the algorithm, hand-eye coordination, and cooperative learning (Socratous & Ioannou, 2018). Lego robotic applications make it possible to bring different solutions to problems in the design and programming process, positively affecting students' problem solving and critical thinking skills. As it allows the testing of algorithms created with block-based visual software on 3D concrete objects, the learner can more easily see his/her mistakes. It is known that Lego robotics applications in the teaching of programming enable learners to participate in the active learning process and support their coding skills (Grandi, Falconi, & Melchiorri, 2014), and contribute to the academic achievement of students (Korkmaz, 2016; Sullivan & Bers, 2017).

On the other hand, basic Arduino kits are used in the process of making high school students gain programming skills who have reached the age of abstract. In the light of the developments in technology in the 21st century, the use of technology in education is increasing rapidly. In studies on the use of robotic systems in education, it is stated that the use of robots in education has positive effects on students' cognitive, linguistic, social, and moral development (Kahn et al., 2012; Shimada, Kanda & Koizumi, 2012; Wei, Hung, Lee, & Chen, 2011). According to Cheng, Huang, and Huang (2013), robotics-assisted learning applications are technological educational applications that increase students' motivation and interest in the lesson and support collaborative learning. It is stated that robotics-assisted learning applications make significant contributions to students' understanding of abstract concepts by providing instant feedback while improving their computational thinking skills (Lee et al., 2011; Rahman, Krishnan & Kapila, 2017; Repenning, Webb, & Ioannidou, 2010; Üçgül, 2017). On the other hand, factors such as inadequacy of class hours, unsuitable classroom conditions, crowded classrooms, and cost are expressed as the main limitations to the use of robotic applications in the literature (Oluk & Korkmaz, 2018; Rahman, Krishnan & Kapila, 2017).

In summary, the usage and design possibilities of robotic systems are quite wide. When the reflections of robotic technologies in the field of education are evaluated, it is seen that the most striking features are the use of high-level robotic systems and the variety of robot designs prepared. The interest in this field in relation to the education policies of countries is increasing. However, the important factor at this point is the decrease in costs and increase in accessibility. The emergence of educational robotic applications with the coordination of science, technology, engineering, and mathematics shows that these applications have a multidisciplinary nature. For this reason, one of the most effective ways of conducting robotic applications in education is STEM education. Developed countries, especially those which want to make an interdisciplinary approach an education policy, use robotic systems effectively in STEM education.

Conclusion

While developments in information and communication technologies greatly facilitate human life, they also support the use of technology in many areas. These developments have caused radical changes in the field of education as in every field and made it necessary to train qualified manpower required by technology. While the use of technology is increasing in the world, the learning-teaching process should be supported with technological tools to keep up with this change. In the process of integrating technology into education, the characteristics of the target audience are important and one of the most important points to be examined in this context is 21st century learner skills, one of the basic elements of the information society.

The standards published by ISTE for learners (NETS-S) cover the competences that learners must have to be successful in all areas of life in the globalizing world. According to current standards, the competences to be possessed by 21st century learners are expressed as follows; empowered learner, digital citizen, knowledge constructor, innovative designer, computational thinker, creative communicator, and global collaborator (ISTE, 2016). Computational thinking is one of the competences to be mastered. Computational thinking skill, which is involved in all areas of life from science to art, which is expressed by Wing (2006) as a basic skill not only for computer scientists but for everyone and which supports 21st century learner skills, has gained more importance and become widespread parallel to the developing technology. Design-based learning activities, especially programming, support the development of computational thinking skills (Peng, 2012).

The importance of education enriched with innovative technologies is increasing with each day to train individuals equipped with 21st century skills and contributing to the creation of productive generation and developed society. Technological innovations that we have come across in recent years affect every aspect of our lives. It is possible to see the effects of technology in almost every field and age group. Innovative technologies, which have become more important and integrated into our life's day by day, naturally affect the field of coding and robotics. With the development of technology, robotic systems have become both more widespread and relatively more accessible economically.

Robotic contents that can be created using robotic systems have a wide range of usage and design possibilities. When the studies carried out in the field of education around the world are examined, it is seen that especially high-level robot systems are prepared, and robot designs prepared with robotic systems are also quite diverse. To keep up with the technological developments of the age, it is important that robotic systems should be popularized in the education world. It is an accepted fact that to train individuals under the guidance of science and technology, technological development should be achieved not only in specific fields (Kwiek, 2018).

When the studies on robotic applications in education are examined, it can be said that the most studies have been done in the field of information technologies for teaching algorithms and programming (Álvarez & Larrañaga, 2016; Grandi, Falconi, & Melchiorri, 2014). In the literature, there are many studies on the benefits of using robotic applications in the teaching process on the learning of individuals. In these studies, it has been revealed that the applications carried out had positive effects on problem solving (Chaudhary, Agrawal, Sureka, & Sureka; Socrataus & Ioannou, 2018; Veselovská & Mayerová, 2015), collaborative working (Chaudhary, Agrawal, Sureka, & Sureka, 2016; Cheng, Huang, & Huang, 2013; Grandi, Falconi, & Melchiorri, 2014; Socrataus & Ioannou, 2018; Veselovská & Mayerová, 2015), project management (Chaudhary, Agrawal, Sureka, & Sureka, 2016), creative and reflective thinking (Barak & Zadok, 2009; Chalmers, 2018) and computational thinking (Chaudhary, Agrawal, Sureka, & Sureka; Lee et al., 2011) skills. Robotic systems allow individuals to develop a product on their own and support learning by doing and experiencing (Alimisis, 2013; Jung & Won, 2018). These systems make it easier for learners to see the mistakes made, as they allow the algorithms created with block-based visual software to be tested on 3D tangible concrete objects. The use of robotic technologies in algorithm and programming teaching, besides providing concrete examples related to real life, contributes to the understanding of programming logic, so it is important to increase studies in this direction.

Today, robotic systems are accepted as a technologically advanced branch of science, and it is a promising technology. With the integration of robotics into learning-teaching environments, breakthroughs similar to the ones taking place in the industrial field are likely to occur in the world of education. In addition to increasing the quantity and quality of the studies carried out by using robotic systems in the field of education, there is a need to carry out new experimental studies that will reveal their contribution to the acquisition of higher-order scientific process skills by students.

When the studies on the use of robotics in education in the world are examined, it is clear that all countries that are advancing scientifically and technologically see robotics as the driving force in education and attach great importance to robotic technology (Koç & Böyük, 2013). While many countries are investing outstanding efforts to make their education systems more efficient by using robotic technology, since robotic assisted learning applications are not fully integrated into the curriculum in our country, they are limited within the framework of certain fields and are mostly carried out in the form of extracurricular activities such as club and workshop activities, special training activities etc. The Ministry of National Education supports these applications by organizing robotics and coding in-service training courses for teachers in recent years (YEGİTEK, 2018). More research and practice are needed by using these applications at different levels and disciplines. In today's world

where the technological transformation called Industry 4.0 is experienced, it is now a necessity to increase the examples of applications carried out by using innovative educational approaches.

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Araştırmanın Etik İzni

Derleme çalışması olduğu için etik kurul onayı gerektirmiyor.

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