A Study on the Development of Robot Education in the Fourth Industrial Revolution

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Abstract. With the development of the Fourth Industrial Revolution, traditional education is evolving into a new education adapted for future society. In particular, with the emergence of artificial intelligence, education targeted at enhancing creativity gets increasingly important. In the future, robots will be used in almost all areas of social life. For this reason, many creative education programs that use robots will surely be developed. In this study, the development trend of robots education programs for children was centrally analyzed. Based on these results, the study further analyzed the current status of robot education. It also suggested the actual practical curriculum of robot education. The results of this study can not only suggest an educational direction for robot education, but also provide with theoretical basis to some extent for future education related to robots.

1. Introduction

1.1. Research Background and Purpose
With the development of the Fourth Industrial Revolution, education technology becomes popular. In addition, in order to improve learners’ creativity, education technology is considered to be the core of future education, which helps develop ways to improve creativity by using robots. As artificial intelligence technology becomes more and more important recently, robots using artificial intelligence becomes new research target. Education on artificial intelligence robot is consequently getting crucial. Generally, computer language such as C language is used to control robots. However, in educational robots, it is very difficult for children to learn computer languages such as the C language. Robot scientists, therefore, try to develop various educational robot programs for children. In light of the above, this study analyzed the current status of robot education. Also, it investigated with examples the learning process of robot education in the United States and Korea. Based on the findings in this study, the development trend of robot education for learners was suggested. The study results can be employed as the theoretical basis for developing robotic education methods for artificial intelligence education.

1.2. Literature Review
The importance of robot education is expanding in the era of the fourth industrial revolution. Robot education also becomes more important worldwide due to the expansion of artificial intelligence
technology. Under this situation, many robot scientists around the world study robot education. So the existing researches on robot education were as follows. Chul Kim (2012) summarized the direction and implications of robot education by analyzing domestic research trend related to robot education and effectiveness papers from 2001 to the recent time [1]. Young Dae Lee et al. (2016) explored program about conventional educational robots, which were commonly known as industrial robots or toy robots, using text-based programming to teach the students [2]. Sang Hee Kim & Sang Un Kim (2017) investigated the research trend of robot education for young children and elementary students as a basic study for the development of hands-on robot program for young children [3]. Sungae Kim & Jihun Koo (2019) verified the effects of a design thinking process-based robotics education program on the creativity of engineering college students in information technology (IT) field [4]. Hyeong Eob Suh (2007) developed a systematic and effective PBL-based robot education program for improving creativity, and analyzed its effect on improving creativity of students in a science high school [5]. Most existing researches of robot education were on the teaching methods of robot education. These findings, however, were limited in practical use. Therefore, this study analyzed the current status of robot education and the educational effect of using robots. And research suggested the new idea to develop robot education. These results could be taken as a theoretical basis for future education in terms of robots.

2. Research Method
As to the research method, this study conducted a literature survey on robot education, which was important in education technology. Literature studies focuses on analyzing books and papers related to robotic education for children, through which this study conducted participation observations in classes that provide robot education to children. In addition, in this study, an in-depth interview was conducted with an educator who provided robotic education. In order to observe and interview, the U.S. and China, where robotic education has developed, were targeted. Eventually, the effectiveness of robot education was analyzed through interviews with learners. This study, as it were, put the emphasis on status analysis of current robot education, and then further on the direction of future education.

3. A Theoretical Study

3.1. Robot
Robots are machines that operate automatically. Some robots are made by imitating human figures. Other robots are made of various looks. Typically, robots can be connected to computers and moved remotely. Universities usually do a lot of research on these robots. These studies are called robotics. In the early days, robots moved through remote control for military use. However, current robots are mostly used in various fields due to the development of artificial intelligence and computers. Robots are generally divided into industrial and intelligent robots. Industrial robots are used in factories and other areas for improving productivity, whose main function is to accept tasks from humans. But intelligent robots, including pet robots, secretary robots, and guide robots, etc., perform various activities mainly to benefit humans. They move based on human movement.

3.2. Child Robot Education
In the era of the Fourth Industrial Revolution, education to enhance creativity among children is highly recommended and valued. Among the burgeoning creativity education programs, those employing robots is arousing great interest from educators and professionals. While the majority of robots have been applied in factories, advances in artificial intelligence have made robots available in everyday life as well as many other areas except industrial production [6]. For example, robots can provide services in various fields. From this point of view, their function could be spread to almost all areas in the future. As the backbone of future social development, children are quite necessary to learn and understand robots by means of robot education, and they also have the advantage to get interaction
with robots in their daily life in this era. They can be more easily to become experts on designing, developing and utilizing robots than elder generations. That’s why nowadays people attribute great importance to children’s robot education. Robot education can be divided into three categories. The first is for children to learn about robots, in which they understand the hardware and software aspects of the robot. The second type is that children learn through robots. They acquire different knowledge through the help of robots. The third is for children to learn with robots. From the above three perspectives, researchers do a lot of research on robot education. Currently, researchers invest a lot to develop programs on robot education. In the near future, government's investment in robot education is also expected to increase significantly [2].

4. Status of Robot Education

4.1. Scratch

Scratch is a computer program developed for education (figure 1). It is a program that educates children through coding. The program was developed by MIT. There are many of robot educational programs. A typical one of them is Arduino. Arduino is a board made to control physical objects [2]. It uses a C++ computer program. Arduino is very difficult for beginners to learn. But scratch is easier for beginners. This is because scratch is made in a way that creates a program through building blocks. Learners can make a program using only a mouse. For this reason, even elementary school students can write computer languages without grammatical errors. Moreover, scratch is free thus anyone can download it easily through the Internet. Scratch can also be used in 40 languages, making it a global children's coding education [2]. Scratch is connected to the robot through a scratch extension module when operators write the computer language on computers. Robots are usually connected to computers based on Bluetooth-enabled wireless communications.

![Figure 1. Scratch](image)

4.2. Robot Education Using Scratch

Robot education becomes very important in the era of the Fourth Industrial Revolution (figure 2). Advanced countries and regions such as the United States and Europe are planning to make robot education mandatory. In 2018, the president recognized the importance of robot education and made it mandatory in Korea.
Figure 2. Robot Education Using Scratch [2]

The user connects the robot’s sensors and motors to the computer. Then the user can adjust the robot using a computer. In the U.S., the toy block Lego is equipped with a motor and sensor. And the sensor connects with the scratch [2]. And the learner can move the Lego through the computer. The courses of robot education in advanced countries such as the United States and Japan are as follows. First of all, educators provide learners with theoretical education based on their understanding of robots. And learners perform the practice of Scratch. Based on theory and practice, learners carry out projects. Learners can feel a sense of accomplishment by directly manipulating the robot through a scratch. As such, the current robot education provides project-oriented education. In order to give such education, the role and professionalism of teachers are important. Therefore, various programs to cultivate teachers are under development. In the future, researchers need to develop diverse educational content on robot education.

4.3. Relating between Robot Education and Creativity
With the development of the Fourth Industrial Revolution, the world will face great transformation in the future. Many jobs that are important now will become redundant and even disappear someday. There will also appear new types of jobs in the future. For this reason, education should perceive the change so as to cultivate the right talent for the future. Creativity is important to create something new in the fourth Industrial Revolution. In the future, there will be rapid changes in all areas, so new technologies must be constantly developed and innovated. Therefore, robot education should be developed in a way that learners can improve their creativity. This method is developed by a robot education program based on Problem Based Learning (PBL) [3]. This Problem Based Learning (PBL) can be used as a method of design thinking. Therefore, Problem Based Learning (PBL) requires creativity to solve problems. And this creativity can be cultivated through self-directed learning. Problem Based Learning (PBL) consists of the process of identifying problems on their own and using knowledge and information to find solutions to problems. And this is a learner-centered education. It allows learners to develop problem-solving skills based on critical thinking. This education aims to cultivate problem-solving skills, not just accumulation of knowledge for learners. In the future, robot education will be an important element of education, and the contents of education will be developed by focusing on creativity.

4.4. Methods and Characteristics of Robot Education Using Design Thinking
With the recent diversification of customers’ needs, companies are increasingly interested in how to solve various problems. For this reason, design thinking, which produces creative solutions based on understanding customers’ needs, is an important method. Educators think design thinking is a very good way to cultivate creativity [3]. The existing method of education was based on conceptual education. In addition, these methods of education were evaluated based on results (figure 3). However, education based on design thinking is a way to value the process rather than the result. And design is basically to analyze the customer’s needs and present the best solution. Design Thinking solves problems through several steps to find the best solution. Therefore, design thinking can be used for robot education to cultivate creativity.
Figure 3. Robot Education Methods

The process of robot education using design thinking is as follows (figure 4). Learners understand robot-related problem situations. They will acquire knowledge about the robot. Through this process, learners select a topic and establish specific problems. Learners then come up with ideas for solving problems and collect data, analyze these data and present appropriate problem-solving solutions. They make prototypes based on ideas. To make prototypes, learners make their own robots using gears, screws, belts, etc. They connect the robot to the computer using sensors, motors, etc. Finally, they make a presentation about the robot using PPT. And through the results, teachers evaluate learners. Learners can cultivate their creativity by using this design thinking method for robot education.

Figure 4. Robot Education Course Using Design Thinking

5. Effect of Robot Education

Currently, the U.S. mandates Lego-based robot education, while Japan is promoting robot education in 2,500 middle schools. Effects of robot education are as below (figure 5).

Figure 5. Effect of Robot Education

Firstly, robot education can interest learners a lot because it is a learning method that has the characteristics of play. Secondly, robot education is related to various fields such as mathematics, physics, and electronics, so convergence education is possible for learners. And now, in most developed countries, robot education is based on mathematics and science. Thirdly, robot education has various educational effects such as creativity as well as logical thinking and problem-solving abilities. Due to this, robot education is expected to expand in the era of the Fourth Industrial Revolution, when creativity is particularly advocated. Fourthly, learners have conversations and discussions with other learners while making prototypes. Through this process, learners can develop cooperative skills. Therefore, robot education will be no doubt a core education course in the future.

6. Development Direction of Robot Education

Currently, creativity is important in education due to changes in the Fourth Industrial Revolution. Experience and practice-oriented learning are important to improve this creativity [5]. And many
countries around the world are attaching increasing attention and importance to robot education. Therefore, systematic robot education should be established in elementary, middle and high schools (figure 6). And future research on learning methods will be needed to arouse students’ interest and encourage them to actively participate. Besides, learning methods should be presented in which students can lead their own learning. Currently, there are not many classes that use robots in most public education. But it is believed, in the future, that robot education will be taken seriously and popularized in public schools. Teachers on account of this will also be required to accept robot-related training programs.

Figure 6. Example of Robot Education

7. Conclusion
With the recent revitalization of robot education, many researchers are interested in the methodology of robot education. In particular, robot education is becoming more important due to the activation of maker space. Therefore, this study analyzed the status of robot education currently in operation. In addition, this study presented the learning process of robot education that is practically usable. Finally, this research also suggested the development direction of robot education. The research results can be applied to practical curriculum and used as basic data for robot education. In the future, research on education programs that can cultivate the role of teachers for robot education is also needed.

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