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A Study on the Effectiveness of a Robotics curriculum based on "Bee-Bot"

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Abstract

This study examined the effects of a robotics curriculum based on "Bee-Bot" on the scientific problem-solving ability on 5-year-old children. A robotics curriculum was also designed to enhance their scientific problem-solving ability. This study examined a 4-week robotics curriculum was conducted 12 times for 4 weeks. For this study, 14 children in kindergarten A in Korea were set up as a treatment group and 18 children in kindergarten B in Korea as a control group. It was found that children in the treatment group who engaged in the robotics curriculum using "Bee-Bot" performed better on scientific problem-solving tests. This finding indicates that an enhanced planning experience using "Bee-Bot" was beneficial for improving young children's scientific problem-solving ability. The implications for designing appropriate curricula using "Bee-Bot" robots for kindergarteners are addressed.

Keywords: *Bee-Bot, Robot based education for children, Scientific problem-solving ability, Robotic curriculum.*

1. INTRODUCTION

Our society is entering into the 4th industrial revolution based on science and technology such as artificial intelligence, the internet of things, big data, etc. This revolution is changing not only science and technology but also society, culture and values. It means that the 4th Industrial Revolution does not affect other things as well as industries [1]. In the past, the paradigm of education changed with the industrial revolution in our society. And the world, which is entering the fourth industrial revolution, is also calling for a change in education [2].

With the development of science and technology due to the 4th Industrial Revolution, there is a demand for a change in education to solve the worries about unpredictable future jobs. In addition, there is rising demands for education that can increase the adaptability to rapidly changing science and technology, rather than knowledge-based injection education[3].

Globally, robotics and computer programming for young children have grown in popularity because of support from governments and private initiatives. The 2015 revised curriculum emphasized education to foster creative and convergent human resources according to the changes of the times, and suggested robotics curriculum that solves real life problems by computational thinking rather than knowledge. In addition, elementary and junior high schools began to apply robotics education in stages from 2018, and in 2019 mandatory robotic curriculum in elementary school for more than 17 hours per year and secondary school for more than 34 hours per year [4].

According to the Nuri curriculum(2013)[5], which is the Korean national curriculum, the direction of the

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Nuri curriculum's composition highlights the attitude you want to resolve when faced with new problems. And It explains that the program aims to achieve full development for children, with an emphasis on fostering autonomy and creativity in education. This can be seen as a robot education aimed at improving the problem-solving skills of real life by using the scientific principles of computers. In addition, robot utilization education is easy and fun to learn by playing with objects that are often encountered around the scientific principles of a hard and difficult computer. In the theory of constructivism, playing has a great influence on development of children, and it is also argued that children can learn through playing [6]. Therefore, robot utilization education in early childhood education is not a heterogeneous approach at all, and if you look at the concepts emphasized in early childhood education and robotic curriculum, you can find common denominators such as problem solving skills, learner-led, and creativity in everyday life. From this point of view, robotic curriculum plays in early childhood education an important role in fostering the scientific problem-solving skills needed in the future society, and these factors are required as essential elements in the rapidly changing future society.

The 21st century is called the era of robots, and technological advances are being made around the world, and the value of our lives is being enhanced by advanced robot technology. By using robots in education, teachers will be able to provide higher quality education by focusing on giving life-wide advice in simple knowledge transfer education. Robots are more important in future societies than they are today. Therefore, we need to teach robot knowledge and skills, and if we take classes using robots, we will be interested in classes and will have an increased desire to learn. Robot education has created a new paradigm for information and communication education, and if education has acquired technical knowledge in the information service society, the educational paradigm of the future is critical for education based on problem-solving skills and computational thinking [7].

Robot-based education helps children form intimacy with robots, interests and curiosity in robot science, and robot-based children education, like other areas, should promote the development of children in all areas of development, and should be used as an interesting and enjoyable learning tool. Children love robots, treat them as friends by personifying them, and social interactions between peers with robots help them develop in society [8]. Robots help shape the positive self-concepts of children, increase concentration, and are effective in learning interests and educational attainments, and frequent contact with robots increases the intimacy of children, which has a positive effect on emotional development [9]. The types and functions of robots vary, and with the introduction of educational robots, they are being used as a new teaching medium for children.

Therefore, the purpose of this study is to verify the impact of robotic curriculum program, reflecting the contents of the Nuri curriculum between the ages of 3 and 5, on the scientific problem-solving ability of children. Through these efforts, the government intends to reveal the applicability and value of robotic curriculum in early childhood education and provide basic data on the development of robotic curriculum programs for various children. For this purpose, we proposed the following research question:

Does a robotic curriculum based on Bee-Bot affect scientific problem-solving ability?

2. METHOD

2. 1 Bee-Bot

The Bee-Bot, selected in this study, is a robot developed by TTS based on LOGO programming for children. The Bee-Bot moves about 15cm forward and backward when pressing the front and backward direction keys, and rotates 90° each time when pressing the right and left directions keys. You can enter up to 40 times, including the direction key and the stop function key. Commands continue to accumulate until you enter the delete button on the bottom left, and when the key input is complete, press the "Go" key to run it. There are LEDs in the Bee-Bot eyes that illuminates when the command is entered, after the command is executed, when it is being charged, and then the sound also indicates the execution state. In figure 1, children are receiving robotics curriculum based on “bee-Bot”. The children thought about the passage through the worksheets where they would move the robot before working “Bee-bot”, and pushed a button to move it. In figure 2, describe functions and configurations of “Bee-Bot”.

Figure 1. Children Participating in Robotics Curriculum

Figure 2. Manual of Bee-Bot.

2. 2 Participants

The study sample consisted of 53 children from two urban private kindergartens in the Republic of Korea. At the time of the experiment, the children were 5 years old. There were 15 girls and 17 boys. The groups consisted of 14 children (girls = 8, boys = 6) in the treatment group and 18 children (girls = 9, boys = 9) from one class in the comparison group. The average monthly age of children in this study was 65.8 months, and the average age of the control group was 67.3 months. t Verification has shown that the monthly age of each group is homogeneous in the monthly age ($t=1.478$, $p>.05$). Both groups of teachers are majors in early childhood education, and the experimental group has 10 years of educational experience and the control group has 6 years of it.

2. 3 Study tool

To measure the children's scientific problem-solving ability, we adapted the Korean version [10] of Tegane, Sawyer and Moran's (1989)[11] original scientific problem-solving ability instrument. This instrument measures young children's problem-solving ability across various questions. We adapted this instrument to examine the effect of children's scientific activities using robotics on their scientific problem-solving ability. After a review by two early-childhood experts to confirm the instrument's developmental appropriateness and validity, some tasks were modified slightly to enhance clarity and efficiency. The 'Problem-solving ability test' consisted of a three-step process of finding and stating problems, proposing and applying ideas to problem solving, and concluding problem solving. This, in turn, was divided into six sub-stages: attention to the teacher's problem presentation, interest in the problem, can explain the problem in one's own words, can suggest one's idea, apply the idea, and conclude around the results. Pre-test of activities to detect scientific problem-solving skills suggested activities using whistles and syringes, while post-test suggested activities using combs and wheels to exclude the effects of pre-examination. Each measurement item was given a score of 0 to 3 on the four-point scale according to the evaluation criteria presented, so that the total score was equal to the lowest of 0 to the highest of 18 points, and the higher the total score, the higher the scientific problem solving ability

2. 4 Study procedure

A quasi-experimental design was adopted with pre-test and post-test samples, which were conducted with an untreated comparison group. Two kindergarten classes were separately designated to be a treatment group and a comparison group. This study included pre-tests and post-tests in both groups. In both the treatment and comparison groups, the children were tested to determine their scientific problem-solving ability. Each kindergartner spent 25 min on the pre-tests and post-tests. The robotics curriculum was performed 12 times over four weeks in 2019, and a post-test was administered to each kindergartner

The pre-test of this study was conducted on April 19, 2019. The pre-test was conducted 1:1 by the examiner and the child in a quiet classroom away from the classroom. The post-test was performed in the same way as the pre-test on May 20, 2019.

The robotics curriculum used in this study was developed by one professor of early childhood education based on the instructions for teachers of Nuri curriculum by age 3 to 5, and was verified by one child education expert, one robot expert, and one computer engineering professor. In addition, the program was organized to facilitate handling of children who have not used the robot. Accordingly, the 12th robotic curriculum program was conducted and the activity was organized based on the national level curriculum, consisting of 3 activities related to 'subject 1', 4 activities related to 'subject 2', and 5 activities related to 'subject 3', and the goal was set so that the concept could be learned from the basics for the systematic computational thinking of children.

Table 1. Four weeks of robotics curriculum in the experimental group

Number	Activity goal	Activity contents
1	Exploring	Have an interest in Bee-bot and exploring the keys of Bee-Bot.
2	Understanding Bee-Bot's Function	Understand concepts of the button function of Bee-Bot, and work with friends to solve problem by making the robot to bring fruit to exit.
3		Understand the concept of button function of Bee-Bot, and work with friends to plan the route and move Bee-Bot.
4		Take an interest to the insects you see in spring, and work with your friends to solve the problem of how to get a robot to meet a butterfly.
5	Learning Bee-Bot's Function	Understand the various ways in which a robot can reach its destination, and talk about how it can escape obstacles to its destination.
6		Find out the fastest way to go to school, and use a mission card to do the task with a friend.
7		Work with my friend to manipulate the fastest way to get to the exit to avoid the obstacles of a car.
8	Applicating Bee-Bot's Function	Understand the concepts of ascending and descending numbers.
9		Find out what the various road signs mean and work with friends to solve the problem so that the robot can get out of the exit to avoid the sign.
10		Recognize the concept of the large and small of numbers, and cooperate with friends to help Bee-Bot accomplish their errands well.
11		Understand the concept of the sum of numbers, learn how to make a number 7 with two numbers, look at the map and see the right path to the destination.
12		Understand the concept of the whole and the part, and predict the picture that will fit into the empty part

During the robotics curriculum implemented after the pretest, the kindergarteners were engaged in two stages of foundational activities and applications that consisted of four and eight activities, respectively (see Table 1). In the foundational phase, four or five kindergartners comprised one group and shared ideas on how to operate the Bee-Bot. For example, kindergartners were educated on topics that included turning on the Bee-Bot, entering right directions to make commands, and running the entered commands to move the robot.

The researcher administered the application phase in small groups within the treatment group. Each activity in the phase took 20 to 25 min. At the beginning of the phase, a researcher introduced that day's activity to the whole class and allowed them to practice with a problem. Subsequently, two or three kindergartners were assigned to a group, and a personal worksheet was provided to each student. The group operated a Bee-Bot and collaborated to solve the problem. The all activities in the application phase began with working on the worksheet. Before operating the Bee-Bot, the kindergarteners practiced their strategy in advance using the worksheet. They used the pens and stickers whose colors corresponded to the command cards to draw arrows on the worksheet and then entered same directions to operate the robot. If the kindergarteners wanted to retry the activity after a failed attempt at problem-solving, they were allowed to do so. It was also placed in the science area of the experimental group's classroom so that the robot could be freely explored during free choice activities.

2. 5 study data analysis

In the pre-test of kindergarten's age comparison and scientific problem-solving ability, independent sample t verification was conducted to determine if the experimental group and comparison group were homogeneous. And, the data from the pre- and post-tests were analyzed using descriptive statistics and an analysis of covariance (ANCOVA) using a significance level of 0.05. A one-way ANCOVA was employed to evaluate the children's scientific problem-solving ability in the treatment and comparison groups.

3. RESULT

3. 1 Scientific problem-solving ability

Table 2 Results of pre- and post-test by group of scientific problem-solving abilities

	source	SS	df	MS	F
Finding and stating problems	pre(Covariate)	47.676	1	47.676	39.221
	group	15.944	1	15.944	13.116***
	Error	35.252	29	1.216	
	Total	106.719	31		
Proposing and applying ideas to problem solving	pre(Covariate)	17.296	1	17.296	18.475
	group	26.069	1	26.069	27.846***
	Error	27.149	29	.936	
	Total	63.500	31		
Concluding problem solving	pre(Covariate)	.201	1	.201	.424
	group	2.889	1	2.889	6.102*
	Error	13.728	29	.473	
	Total	16.719	31		
Scientific problem-solving ability Total	pre(Covariate)	172.475	1	172.475	57.292
	group	126.572	1	126.572	42.044***
	Error	87.303	29	3.010	
	Total	378.875	31		

$^*p<.05$, $^{***}p<.001$

As shown in Table 2, after adjusting the scientific problem-solving test score of the pretest to the covariate, F = 42.044 (P <.001) showed statistically significant difference on scientific-solving ability scores among the groups. Looking at the subcomponents of scientific problem solving, F=13.116, p=.000 in 'finding and stating problems', F=27.846, p= in 'Proposing and applying of problem-solving Ideas'. Both all showed significant differences at the significant level .001. Also, data was shown that F=6.102, p=.02 in 'Concluding problem solving' which meant that there was a significant difference at the significant level .05. Through these results, it can be interpreted that robotics curriculum based on Bee-Bot had a positive effect on improving the scientific problem-solving ability of 5-year-old children.

4. DISCUSSION AND CONCLUSION

The goal of this study is to examine the effect of robotics curriculum based on Bee-Bot on the scientific problem-solving abilities of 5-year-old children during 4 weeks of activities enhanced with complementary action. For this purpose, the robot utilization training based on the robot is applied to 5-year-old children and discussed based on the results as follows.

First, robotics curriculum based on Bee-Bot turned out to have a positive effect on the scientific problem-solving abilities of kindergartens. More specifically, the 'total' score of 'scientific problem-solving abilities' and the scores of 'finding and stating problems', 'proposing and applying ideas to problem-solving' and 'concluding problem solving', have shown that the experimental group has significantly higher scores than the control group. This can be seen as a result of the positive impact of robotics curriculum based on Bee-bot on the development of scientific problem-solving abilities in 5-year-old children.

The limitations of this study and suggestions for further study are as follows. First, since this study was selected for kindergartens who apply to child education institutions located in Korea and was conducted in a short period of four weeks, there are limitations in generalizing the research results. This requires further study, including the subject and the period of study, considering the various regions. Second, this study confirmed that robotics curriculum based on Bee-Bot has a positive effect on the development of children. This is the same as [12]'s research that helped improve the 'problem-solving abilities' required to become a fusion person in the era of the 4th Industrial Revolution and is in line with the results of [13].

Therefore, the results have important implications that prove the value of robotic curriculum. Third, however, since the development of education programs based on the national level curriculum is insufficient and the training of teachers and the re-education of teachers is not reflected at all, the development of robotic curriculum programs and various types of teacher education needs to be planned. Fourth, although this study proved its effectiveness by quantitatively analyzing the results related to problem solving power, it may be necessary to follow up on the results through qualitative research methods. Finally, early childhood education is the beginning of all education and the first step in preparing for our future.

Therefore, supporting education and developing relevant education programs for children who will be the main characters of the future in a changing era is a matter of great national importance. Future human resources development should be dealt with at the level of lifelong education, including kindergarten, elementary, middle and higher education and vocational education, and is possible through systematic education in the national system. Beyond education experts, I hope that the interest and support of other academic experts and the convergence research that they are the main players will continue.

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