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[1]Universitas Putra Indonesia "YPTK" Padang, Indonesia
[2]Universiti Kebangsaan Malaysia, Malaysia
[3]Universitas Mercu Buana,
[4]Queen Mary University of London, London

*mardhiah_m@upiyptk.ac.id

Abstract. Creativity is a very important skill that should be possessed by the human resources of a country, especially in this period of the 21st century. Human creativity must be stimulated from various things, including via the field of education to improve the quality of human resources. The goal of this study was to investigate the impact of Lego Mindstorms as learning tools to improve the creativity skills of students, using an experimental methodology. We used a random sampling technique to select 40 students as the sample (N=40) for the study, with age ranging 10-12 years old; the sample was divided 2 groups, 20 students were assigned to the control groups, while the other 20 students formed the experimental groups. The student's creativity skills were taken from a figural creativity test (TKF). This test was conducted before the intervention (pretest) and after the intervention program (posttest). In the intervention program, the experimental group students were given some education about robotic technology via the use of the Lego Mindstorms tools. To analyze the test results, we utilized the Statistical Product and Service Solutions package. The finding showed that there are significant differences between the creativity scores of students in the experimental group and the creativity scores of the control group. The Lego Mindstorms influences the enhancement of student's creativity of around 23.6% in the experimental groups.

1. Introduction

In the recent years, robotic technology has been of great interest of exploration by many researches, because as a new technology it is very useful to the human live. Robotics technology has also influenced several developments in the sector of education; hence, educational Robotics is a field of study that aims to improve the learning experience of people [1], some scholars have also ascertained that robotics education is an appropriate and meaningful learning opportunity for children [2]. Furthermore, the use of robotics technology as an educational tool is considered to have a positive impact on students in the form of increasing so many skills such as creativity; that robots can be a tool that can enhance the skills of

children [3]. Researchers have identified new challenges and trends focusing on the use of robotic technologies as a tool that will support creativity and other 21st -century learner [4] [5]. Figure 1 shows the important skills in the 21st-century learner [4].

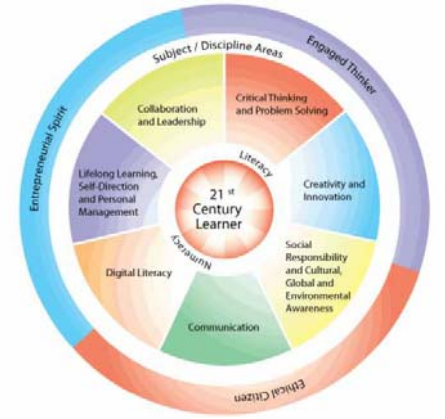

Figure 1. The Important Skills in 21st Century Learner [4]

Based on figure 1, creativity is a very important skill to have and develop in the 21st century. Creativity has been defined in different and numerous ways; also some skills can be developed by creativity, some of which are: divergent thinking ability, having a vast knowledge, communication with other people, as well as personal capacity for critical analysis [6]. Comprehensively, creative thinking has been defined as the thinking that enables students to apply their imagination to generating ideas, questions and hypotheses, to experiment with alternatives and to evaluate their own ideas as well as that of their peers' ideas, final products and processes [7].

Many researchers support robotics as an educational tool, hence, one of the most interesting robotics technologies that can be used as an educational tool is the Lego Mindstorms kit, due to reason being that it can develop many skills of students. Lego Mindstorms can improve students' problem solving and algorithmic skills [8]. More so, a robotic system can bring the possibility of transmitting to children, the basics of technology and helping to give them other kind of human and organizational values. With robotics the students can have a different opportunity for developing their logical ability and their creativity, features at the base of reasoning and critical thought [9]. It has also being discovered that students who studied about robotics, have attained greater metacognitive and problem-solving skills [10].

Furthermore, Lego-based Robotics can allow students to develop different solutions to the same problem, in a bid to provide a learning community [11]. Lego Mindstorms robots has been used to further develop learners to "think out of the box", firstly to further reinforce fundamental computer programming concepts that had been partially developed. Secondly it has been used to increase the interaction between learners and generate higher motivation and interest in computer programming, improve their problem solving or algorithmic skills, simulate creative thought and develop critical thinking, collaborate with peers and learn socially and motivate them to achieve and become creative in their thinking [12]. Lego Mindstorms also gives a positive effect to student's creative problem-solving skills and their post-education performance [13]. Interestingly, the application of Lego Dacta in central Sweden has been able to give a positive effect on students' performance in mathematics [14]. Hence, using robotics and Lego Mindstorms, can also increase the ability of students in physics and in the design of engineering concepts [15], as well as increase the ability of students in the STEM concept [5] [16] [17].

Although many studies have been done on the effect of Lego Mindstorms as an educational tool for creativity skills, more studies still need to be conducted, especially in the aspect of measuring the effects of Lego Mindstorms on creativity with standardized measuring instruments.

The purpose of this study was to investigate the effect of Lego Mindstorms as an educational tool for the creativity skill of students. The results of this study may provide some vital suggestions to the educational sectors, to be able to involve innovative technology in educational processes, so that they can stimulate and develop the personal skills of students.

2. Method

2.1 Participant

The participant in this study were 40 elementary school students (N=40) with age range 10-12 years old from private elementary schools; the selection of schools and students was done by random sampling techniques.

2.2 Instruments

Creativity of students was measured by a Figural Creativity Test (TKF). The Figural Creativity Test (TKF) is an adaptation of the Circle Test made by Torrance, which was then standardized in 1988. The creativity measured in TKF provides an understanding of the ability to form new combinations of given elements reflected in the fluency, flexibility, originality, and elaboration. Some elements that determine the figural creativity of students is also present in literature [18], [19], [20], [21].

2.3 Procedure

The study employed an experimental methodology, wherein a pre-test and post-test repeated measures was designed with a control group, to know the creativity of students before and after the intervention of Lego Mindstorms as a learning tool. Hence, the procedure in this study was divided into 3 phases:

1. The first phase is the pre-test, this step was used to determine the creativity of the students (control group and experimental group) before the intervention. On the TKF, the total score was calculated from the number of characteristics that appeared on each student's answer. Implementation of the figural creativity test involves three steps. In the first step, the students were asked to create an image of a pattern that has a predetermined pattern in a circle. For the second step, students were asked to complete an image based on the pattern that has been provided. With regards to the third step, students were asked to create an image which varies as much as possible and within 10 minutes it should have been determined using a circular pattern that has been given [22].
2. The second phase was an intervention, as such, the experimental groups were given the intervention in the form of learning about robotics technology by using the Lego Mindstorms Tool in four meetings with the duration of each meeting lasting for about 3 hours.
3. The Last phase is the post-test, in this phase, the same pre-test instruments were administered to the students, as this step aims to know the figural creativity of students after the intervention (control group and experimental group).

2.4 Intervention

This section describes the activities that was developed with children about the subject of robotics technology by using Lego Mindstorms. This intervention was done in four meetings.

Table 1. Learning Robotics Technology with Lego Mindstorms Schedule

Meetings	Activities	Duration
1	Introduction about robotic technology, specially about Lego Mindstorms, explanation about materials and equipment	2h.30min
2	Introduction about mobile robot, Create Tracker Tank Bot	3h.10min
3	The robots based on student's creations	3h.25min
4	Develop student's creations robot for competition	3h.

The meeting began with the quest for the students to make groups and sit in a circle, the students listened to an introduction about the materials of the robotics technology, via an audio visual media; the activity gave a deeper knowledge about robotics technology and the control system of a robot. The explanation was furthered to the Lego Mindstorms, which was the experiment tool used in this study. This activity was given so that students can distinguish and know the function of each Lego Mindstorms kit based on shape and colour. Lego Mindstorms is an assembly kit that contains building block pieces (construction kits) and a programmable control unit that can enable one to build a number of robots [8] [23][24]. This kit includes all the important components needed to build a robot, such as connectors, axle, busing, beams, frames, tubes, gears, belts, shafts, wheel, motors, sensors, and control center.

Control center in Lego Mindstorms is the Brick. The Brick can send a programme to the motors, receive information from sensors, among other functions. Additionally, the Lego Mindstorms consist of a large motor and a medium one as an actuator. It also comprises of different sensors: the colour sensor, ultrasonic sensor, touch sensor, infrared sensor, gyro sensor, and the temperature sensor. This description was accompanied by displaying each of the components.

Figure 2. Teacher explanation about the components of Lego Mindstorms

After introducing the Lego Mindstorms kits and the students were able to understand about the function of each components in the first meeting; the second meeting however focused on the explanation about the mobile robot, also in this meeting, the robot development project commenced. The students were able to get new experiences with the robotic lesson via thee medium of Lego Mindstorms. The projects achieved by the students were, the making of a tracker tank bot, as the students were adequately taught on how to design, construct, build and control a robot.

Figure 3. Students make tracker tank bot

In the third meeting, the students were asked to make robots based on their own creations in groups, which was aimed at hoping to improve their skills in creating a new way, creating a new thing, collaboration, teamwork, listening to the opinions of friends in one team, expanding, imagination, as well as modifying.

After that, the students were asked to give presentations on the explanation of the robot they had created, some of which included, the means by which such robots can interact with the environment, and the benefits of their robot. This activity was aimed at stimulating the students' skills to speak in public, convey ideas, learn how to deal with problems, as well as how to make up a story.

Figure 4. Students explain their robot

In the last meeting, students were asked to develop their robot and to get prepared to compete with other teams. This activity was aimed at stimulating their teamwork, fluency in thinking, and decision making.

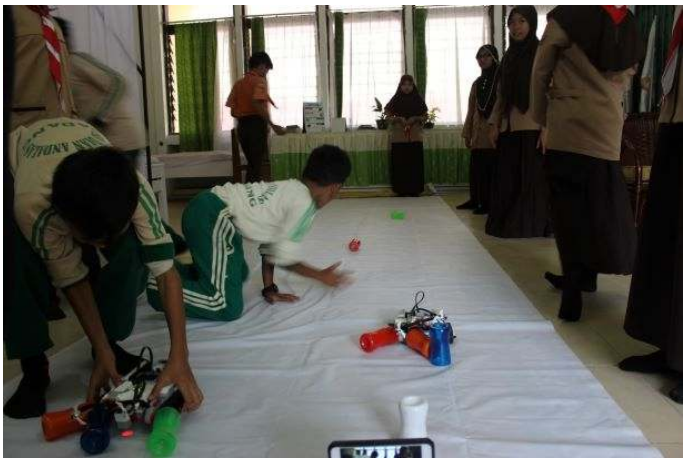

Figure 5. Robot competition

3. Results

To analyse the results of this study, statistical analyses were done by using the Statistical Product and Service Solutions. The result of the descriptive statistics for the figural creativity test (pre-test) is presented in table 2.

Table 2. Descriptive Statistic Creativity of Students in pretest

Experimental Group (N=20)		Control Group (N=20)	
Pretest		Pretest	
M	SD	M	SD
94.95	7.584	94.35	5.696

Table 2 shows that the mean values for creativity on the pre-test, that is the experimental group (M = 94.95; SD=7.58), and control group (M =94.35; SD = 5.69), were not significantly different from the mean values on the pre-test.

The next analysis was carried out to find out whether there was a change in the value regarding the creativity of students after the intervention, especially in the experimental group. In accomplishing this, a paired sample test analysis was carried out, and the results of this analysis can be seen in Table 3.

Table 3. Paired Samples Test

Group	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pre-test Experimental – Post-test Experimental	-22.400	9.098	2.034	-26.658	-18.142	-11.010	19	.000
Pre-test Control – Post-test Control	-9.250	9.547	2.135	-13.718	-4.782	-4.333	19	.000

According to the sig. (2-tailed) value from table 3, the experimental group (sig.2-tailed = .000, p <.05); it can be concluded that there were significant differences between the mean values of the students' creativity before (pre-test) and after (post-test) the intervention. For the control group (sig.2-tailed = .000, p <.05), it can be concluded that there were also differences between the mean values of students' creativity in the pre-test and post-test. Because both of the group have same sig.2-tailed values, table 4 shown more descriptive statistic details.

Table 4. Descriptive Statistic Creativity of Students in pre-test and post-test

Experimental Group (N=20)				Control Group (N=20)			
Pre-test		Post-test		Pre-test		Post-test	
M	SD	M	SD	M	SD	M	SD
94.95	7.584	117.35	9.320	94.35	5.696	103.60	8.120

Based on table 4 shows that the mean values for creativity of the post-test, as given thus: experimental group (M = 117.35; SD=9.320), and the control group (M = 103.60; SD = 8.120), were significantly different from the mean values of the pre-test.

$$\text{Different value} = \frac{\text{Mean posttest} - \text{Mean pretest}}{\text{Mean pretest}} \times 100\%$$

The creativity of students after getting the intervention of Lego Mindstorms, which was used as an innovative educational tool in the experimental group, increased to 23.6%, but the creativity of students in the control group, that is the group where students did not get any intervention only increased to 9.8%. The intervention had an important impact on the creativity of the students, and there was a great significant difference between the experimental group and control group, with a higher increase of creativity in the experimental group.

4. Conclusion and Discussion

Based on the result of this study, integrating technology in the education sector, especially robotics technology has been able to provide a positive impact on students. It has been proved by introducing students to the robotics technology through Lego Mindstorms as an educational tool, to stimulate the creativity of students; of which in the experimental group, creativity had a significant increase of 23.6%.

This is consistent with several studies that have been done before such as the works of Ahmad Khanlari in 2013, where it was revealed that robotics improves some of the students' skills, such as creativity, critical thinking, team work and collaboration skills, self-confidence, sociality, and tendency to help others. The results of the study also reveals that robotics has a great impact on the 21st century skills [25], hence, educational robotics is an all-in-one technological learning tool that promotes the future success of the students [5], also, robotics is one way of fun learning that can make students think more creatively in creating something new [26]. Therefore, robot can be used by children as a tool to boost new ideas and stimulate their creativity [27], based on the potentials of educational robotics which has been acknowledged earlier, in particular, the potential to facilitate curiosity and creativity [28].

The ability to come up with creative new ideas are of extraordinary importance to cultural development and the progress of human civilization [29]. Thus, if the individual creative skills that will impact personal quality is getting better, and if there are a lot of creative individuals, it will make the quality of human resources in a country to be better; also the formation of a creative society will improve the competitiveness of a country. A creative society can help in providing a positive impact in improving the economic aspects of a country [30].

It is important to state that creativity skill has a correlation with innovation, because good creativity skills can create innovation. Thus, innovation and creativity are fundamental to all academic disciplines and educational activities, not just the arts. The creative process, as with the reflection considered in the previous sections, is a critical component that deals with making sense of learning experiences. A number of approaches to teaching and learning have been considered in this paper that can help to nurture creativity and innovation [7]. Creativity is one of the most sought-after competencies, due to the move from industrialized economics, wherein the ability to innovate is crucial for the workforce [27]. Hence, a creative society will produce many innovative works.

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UNIVERSITY OF MALAYA

CERTIFICATE

BILLY HENDRIK

PARTICIPANT

In International Conference On Computer Science And Engineering
"Strategies to Face Industrial Revolution 4.0"
on Friday-Saturday , April 26-27th, 2019 at UPI Convention Center, Padang, West Sumatera, Indonesia

Rector
Universitas Putra Indonesia "YPTK" Padang

Prof. Dr. H. Sarjon Defit, S.Kom., M.Sc

General Chair

Billy Hendrik, S,Kom., M.Kom