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A New Robotic Learning Activity Design to Increase the Figural Creativity: Originality, Elaboration, Flexibility, and Fluency

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***Abstract*— Preparing a generation that possesses the skill of Figural Creativity (FC) skills is important in education because figural creativity skills are needed in the industrial revolution 4.0 (IR 4.0) era. Figural creativity skill is the ability to create something new, a new manner, and produce something different from its initial state in providing solutions to the problems faced. One of the IR 4.0 technologies that can improve creativity is robotic technology, but the implementation of robotic technology in education still requires an appropriate learning activity. This study aims to design the new robotic learning activities and analyze their implementation to increase Figural creativity variables. Figural creativity variables consist of four variables: elaboration, flexibility, fluency, and originality. A total of 23 students were recruited in a user study experiment, ages 9-12 years old. Figural creativity skill of students measured by Figural Creativity Test (TKF). This study used mix method approach. The results showed that the new robotic learning activity design could fulfill the valid criteria; expert suggestions are subject to fixing this learning activity. The new robotic learning activity design was implemented in the robotic course. The paired sample t-test showed that robotic learning activity design has a significant difference between pre-test score and post-test score, and it can improve students' elaboration, flexibility, fluency, and originality. It has a growing impact on all figural creativity variables (fluency = 60.9%, flexibility=56.6%, elaboration = 26.6%, originality =39.3%).**

***Keywords*— Robotic technology, learning activity, robotic effect, figural creativity.**

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I. INTRODUCTION

Knowledge of technology has great importance in enhancing and developing the skill of humans to attain a good quality of human resources [1]. Creativity skill is one of the important skills that must be possessed to compete in the IR4.0 era. Creativity is very important because creativity is central to the innovation process [2]–[4]. The first step of innovation is creativity, innovation is essential to long-term strategic success, and sufficient ideas are effectively implemented [5]. Increased creativity skills can be obtained by learning technology because creativity is related to technology [6]–[8]. Thus, the application of technology in the education sector can support the development of creativity [9].

One of the technologies in IR4.0 Era that can contribute to education and is in great demand by the Z generation is robotic technology. The many benefits of robotic technology in education resulted in the emergence of robotic learning. Masril *et al.* [10] stated that the teacher's acceptance commonly agrees that robotic as learning tools can increase teachers' productivity and be useful for students. Several studies have been carried out on robotics courses. Robotics can be a tool that can be used to teach twelve-year-old students. Some of the basic concepts of geometry can enhance the skills of the students [11]. The usage of robots in education is known to increase students' interest in STEM [12]. The LEGO NXT, as a kind of robotic in education, has the potential to integrate into the teaching and learning of physics [13]. Robotics is a useful aid to mitigate the lack of interest toward STEM subjects and facilitate students' learning of STEM subjects [14]. In fact, 80% of educational robotics experiences take place in the field of mathematics or physics [15]. Another study revealed the effect of robotic technology on the creativity of students. Badeleh [16] stated that using human-robot as an educational tool could improve students' creative expression by about twice the amount of imaginative expressions compared with PowerPoint as an educational tool. Furthermore, Social Robot positively impacted improving creativity in elementary school students [17]. LEGO Mindstorms is a robotic kit that the students are taught how to design, build, and program robots by their teacher. These activities can stimulate the creativity of elementary school students [1]. Gorakhnath and Padmanabhan [18] stated that educational robotics in the classroom allows students to express themselves freely and promotes the development of creativity and imagination. The use of robots as an educational tool can improve the creative expression of participants, such as generating a new use of a tool, creating a new effect, transforming a technique as compared to creative expressions of participants using PowerPoint as a learning tool [19]. The application of robotics in learning technology potentially helps in improving students' creativity [20]. Many studies show that robotic technology can be educational tools to stimulate students' creativity.

However, in implementing robotic courses, the important problems are that it requires educational theories, teaching methods, teaching philosophy, and learning activities design [12], [17]. Based on the existing literature, the learning activities design on the robotic course is unclear and needs more study about it; teachers needed learning activities to make their learning activities according to the learning objectives. This research aims to create new learning activities for robotic learning, focusing on improving all figural creativity variables, such as fluency, flexibility, elaboration, and originality. This research was significant because creativity is linked to fluency, flexibility, originality, and elaboration. The ability to generate new ideas easily (fluency), the ability to generate varied ideas (flexibility), the ability to generate innovative ideas that are distinct from current ones (originality), the ability to create ideas from existing ones (elaboration). The impact of this learning exercise on improving figural imagination variables. This study's findings are intended to close the distance between developments in robotics technologies as learning instruments and the related learning activity in robotic courses.

II. MATERIALS AND METHOD

This study used a mix of qualitative and quantitative methods. The systematic steps of the study are shown in Fig.1; it shows that the research consists of 3 steps.

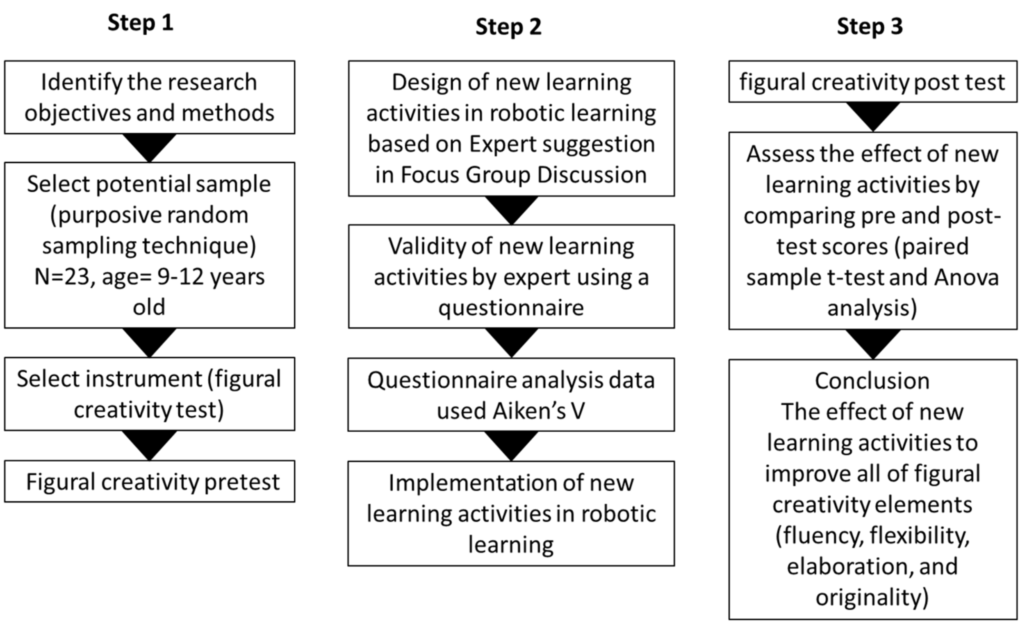

Fig. 1 Systematic steps of research

A. Step 1

The first step is the initial steps, consist of 4 sub-steps.

1) Objectives: The objective of this study is to create new learning activities for robotic learning to improve all of the figural creativity variables, such as fluency, flexibility, elaboration, and originality.

2) Sample: The sample in this study comes from private primary schools in Padang, and Padang has been selected because it is regarded as the most famous educational area in Sumatra Island, Indonesia. The sampling used a purposive random sampling technique, the total participant in this research were 23 students, who have aged 9 until 12 years old, and in this age range, the growth of creativity is about 50% to 70% [21], [22]. Students are in the concrete operational stage at this age level, in which they have the potential to think rationally, imaginatively and can consider more problem-solving objects or scenarios. The step of a concrete operational in which young children improve their reasoning skills will also rely on logic, according to Piaget's theory of cognitive growth [23]–[25].

3) Instrument: Figural Creativity Test is used to measure students' FC. The measurement of creativity, Torrance developed the Figural Creativity Test, which is the most widely used today, and is known as the Torrance Tests of Creative Thinking (TTCT) in the form of tests that involved completing the picture (i.e., drawing completions test), referred to as the Wartegg test [26], [27]. The Figural

Creativity Test involves the sample in completing the picture (i.e., drawing completions test), referred to as the Wartegg test [26], [27]. Creativity is assessed with an awareness of the ability to produce new combinations of certain variables expressed in four variables. Further, the FC scoring is based on the marks given to four variables: elaboration, flexibility, fluency, and originality [28]–[30], as shown in Fig. 2.

4) Figural creativity test: Figural creativity test (pre-test) to assess the FC skill of students prior to the intervention. In a group administration session, the pencil and paper assessments were performed individually, and the figural creativity test consists of various activities. A circular pattern is introduced to the students, and students are asked to create as many different images as possible, and it must be calculated using the specified circular pattern within 10 minutes; In addition, students are asked to include the title of each picture based on the pictures that have been created [31], [32]. The cumulative score is converted into standardized scores, and then the sum of the row scores becomes the score of the creativity quotient; The creativity quotient score with intervals was translated into four levels; superior, high average, average, and low average [33].

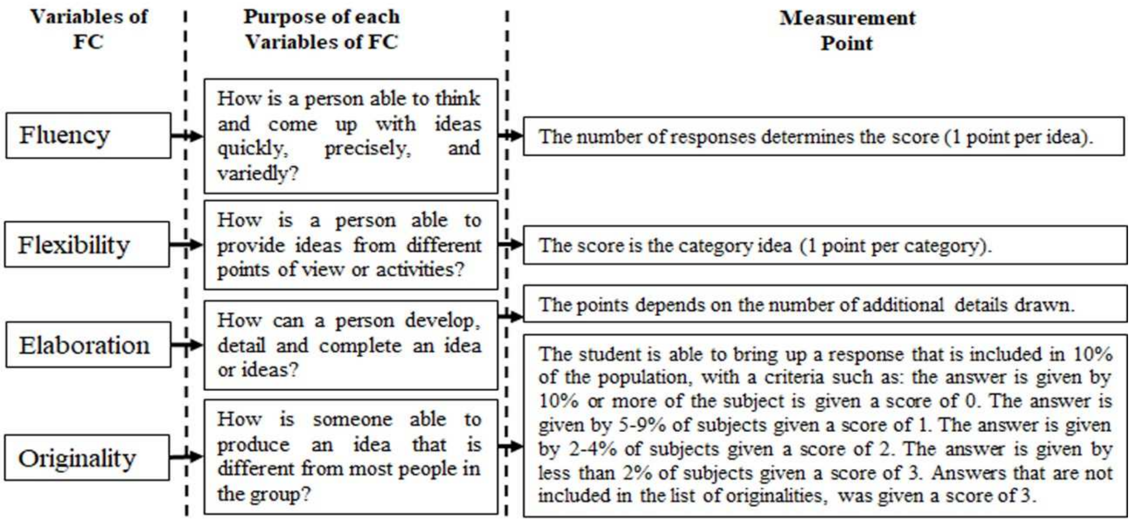

Fig. 2 Measurement points for variables of figural creativity

B. Step 2

The second step is implementation, which consists of 4 sub-steps.

1) Design of new learning activity in robotic learning: The learning activity was developed by an expert's suggestion, which was invited in the Focus Group Discussion (FGD). The learning activity concept was developed to increase the four variables of the FC [34]. This program includes some activities. Firstly, the first element is fluency, coupled with activities, imagination, discussion, and competition. Secondly, the second element is flexibility coupled with activities modification and negation. Thirdly, the third element is originality, coupled with creating a new robot and a different answer. Fourthly, the fourth element is elaboration coupled with activities involving stories and concretizing. The initials and expertise of the invited experts were KR and JJ as education experts, HT and R as psychologists.

2) Validity of new learning activity by an expert: Validity of new learning activity was assessed by an expert using a questionnaire.

3) Data of questionnaire: Questionnaire data were analyzed using the results of the validity coefficient Aiken's V.

4) Intervention or implementation of new learning activities: Intervention or implementation of new learning activities students actively interacted in robotic learning with the new design of learning activities.

C. Step 3

The third step is evaluation, which consist of 3 sub-steps.

1) Figural creativity test: Figural creativity test (post-test) to assess the FC skill of students after the intervention. After the new design of learning activities intervention was completed, the students' FC was measured by using the Figural Creativity Test (Post-test). It is important to do a post-test to find out how much the FC of the student has improved. The pencil and paper assessments were performed individually in the group administration session. The post-test figural creativity test has the same operations as the pre-test. The cumulative score is converted into standardized scores and the total raw scores into creative quotient scores; thus, the creative quotient score was translated into FC levels.

2) Analyzing: Analyzing the effect of the new learning activities in robotic learning to stimulate all the FC variables used paired sample t-test and ANOVA analysis. Data analysis was performed with SPSS software.

3) Concluding: The conclusion of new learning activities to improve all figural creativity elements.

III. Results and Discussion

In this section, a discussion was made about the learning activity design for robotic learning and the effects of applying this learning activity to improve students' FC; to know whether there are differences between the FC level of students before the intervention and the FC level of students after the intervention.

A. Learning Activity Design

Learning activities are designed based on activities that can stimulate creativity. According to Kim *et al.* [35], some activities such as imagination, modification, negation, and competition by utilizing objects around students can stimulate student's creativity. Stolaki and Economides [36] argue that several activities such as collaborative team, game-like competitive environment, question and answering by utilizing Information and Communication Technologies can increase student's creativity, another opinion by Hoffmann and Russ [37] that activities in the form of pretend games, storytelling has benefits in increasing creativity. This study designed learning activities based on the characteristics of each figural creativity variable by integrating robotic technology.

Fluency is the ability to answer questions as much as possible within a certain time, this capability is important, and its stimulated so that students are accustomed to thinking quickly. Further, the activity task for fluency, including imagination, discussion, and competition, is described below:

1) Activity-1 Imagination: In this activity, the students were shown an object or a component, after which they were asked to imagine if the object was a part of a robot. Also, the students were made to think about how to design and create a robot from the imagined object.

2) Activity-2 Discussion: Students were given time to ask questions on materials that they were poorly understood or not understood at all in the first place. In addition, the teacher provided several explanations hinged to opportunities for discussion, this activity aimed at making the students have a broader understanding of robotic technology, which has been learned already.

3) Activity-3 Competition: Some exercises on robotic technology given to the students were intended to produce works that can create competition among their peers or teams. This activity made the students work through each exercise quickly, vigorously, thus showing their best abilities. Flexibility is the ability to generate many ideas within a certain time. This capability was importantly stimulated so that students could generate a lot of ideas. The activity task for flexibility, including modification and negation, is described below:

1) Activity-1 Modification: In some of the exercises related to robotic technology, students were asked to modify the robot provided by the teacher, this activity aimed at enabling the students to practice their skills in developing ideas.

2) Activity-2 Negation: In this activity, the students were asked to compulsively and purposely negate the given objects, students should negate and make new ideas about them, and the activity can give stimulation for students to create a new object and modify the original object.

Originality is the ability to create something new or different from what has existed before, this capability is an important stimulation for students to produce original work and it helps them to be able to create new innovations. The activity task for originality includes new creation and different answers as described below:

1) Activity-1 New Creation (new robot): By the time the students had completed each exercise given by the teacher, the students were asked to design a robot that has never existed, which was expected to differ from the design of other students.

2) Activity-2 Different Answer: In some of the exercises, students were shown pictures or videos from an activity done manually by humans, and after that the students were asked to find the problem and design a robot that can solve the problem, and students were expected to have different answers from that of other students.

Elaboration is the student's ability to present ideas in detail and this capability is important and was stimulated so that the students were able to design something with details and perfection. The activity task for elaboration included making stories and concretizing as described below:

1) Activity-1 Making Stories: Students were asked to present in front of the teacher and other students about what they know regarding robot design, how robots work, the function and benefits of robots, and how robots create purpose.

2) Activity-2 Concretizing: In this activity, students were asked to create an idea of the robot, and they were asked to describe in detail the idea of robots in their minds. The new robotic learning activities design (RL) increases all figural creativity variables, as seen in Fig. 3.

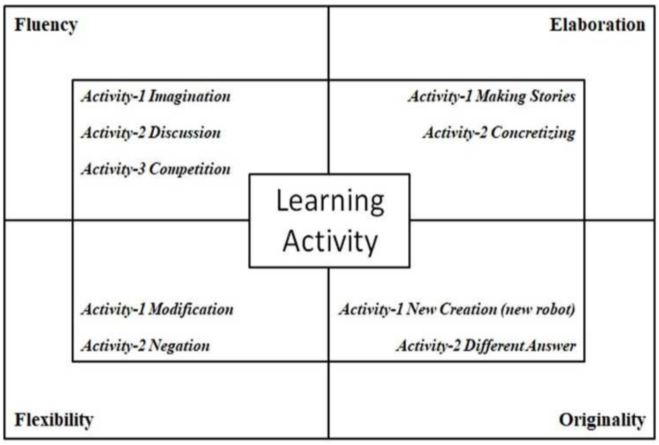

Fig. 3 Learning Activity Design for Robotic Learning

B. Validity of learning activity by expert

Expert validity was verified after the learning experience was designed and explained explicitly, in the four variables of figural creativity the truth dimensions of the latest learning activity in robotic learning were studied. Aiken's V of fluency has a validity value of 0.92, Aiken's V of flexibility has a validity value of 0.91, Aiken's V of originality has a validity value of 0.91, and Aiken's V of elaboration has a validity value of 0.93. Aiken's validity coefficient V of the objects tested is 0.92, indicating that the significance is in the range of 0.60 to 1.0, indicating that it is very accurate, according to the test results of the expert judgment.

C. The Effect of Learning Activity to Improve all of the Figural Creativity Variables

1) The effect of learning activity to improve fluency Ability of Student: The first analysis for fluency. The purpose of this study is to decide if imagination, discussion, and competition activities based on RL, before and after the intervention, there are changes in the fluency capacity of learners. Research Question 1: is there a difference between the pre-test and post-test in the mean values of the fluency ability of students? According to Santoso [38], in paired sample t-test analysis, decision-making recommendations are based on significance values (sig) with the following provisions: if sig. (2-tailed) value<0.05, meaning that there is a substantial difference between the pre-test and the post-test in the mean value of fluency ability, paired-samples t-test for students' fluency ability shown in Table 1. The sig (2-tailed) score is .000 means $P<0.05$, there is also a significant difference between the mean student fluency score before and after the intervention. To find out the magnitude of the effect of robotic learning on increasing student fluency abilities, an ANOVA analysis was performed, and the effect size of the ability fluency ability shown in Table 2. ($\eta p^2 = .609$), it means that the effect size of the robotic learning to increase the ability of fluency is 60.9%.

TABLE I
PAIRED SAMPLES T-TEST FOR STUDENTS' FC ABILITY

Pre and Post Test	Paired Differences		t	df	Sig. (2-tailed)
	Mean	SD			
Fluency	-4.217	2.194	-9.218	22	.000
Flexibility	-3.609	2.148	-8.058	22	.000
Elaboration	-2.478	1.534	-7.750	22	.000
Originality	-11.217	3.965	-13.567	22	.000

2) The effect of learning activity to improve Flexibility Ability of Student: The second analysis for flexibility. The purpose of this study is to determine whether by carrying out modification and negation activities based on RL, there are differences in students' flexibility abilities before and after the intervention. Research Question 2: Is there a difference in the mean score of students' flexibility ability between before and after the intervention? paired-samples t-test for students' flexibility ability shown in Table 1. The sig (2-tailed) score is .000 means $P<0.05$; there is also a significant difference between the mean student flexibility score before and after the intervention. To find out the magnitude of the effect of robotic learning on increasing student flexibility abilities, an ANOVA analysis was performed, and the effect size of the ability flexibility ability shown in Table 2. ($\eta p^2 = .566$), it means that the effect size of the robotic learning to increase the ability of flexibility is 56.6%.

3) The effect of learning activity to improve elaboration Ability of Students: The purpose of this study was to find out whether there are differences in the making of stories and concretizing activities based on the RL elaboration ability of students before and after the intervention. Research Question 3: Is there a difference in students' elaboration ability mean values between before and after the intervention? Paired-samples t-test for students' elaboration ability shown in Table 1. The sig (2-tailed) score is .000 means $P<0.05$; there is also a significant difference between the mean student elaboration score before and after the intervention. To find out the magnitude of the effect of robotic learning on increasing student elaboration abilities, an ANOVA analysis was performed, and the effect size of the ability elaboration ability shown in Table 2. ($\eta p^2 = .266$), means that the effect size of the robotic learning to increase the ability of elaboration is 26.6%.

TABLE II
THE EFFECT SIZE OF THE RL IN ENHANCING STUDENTS' FC ABILITY

Ability	Type III Sum of Squares	Mean Square	F	Sig.	Partial Eta^2
Fluency	164.711	164.711	32.717	.000	.609
Flexibility	112.046	112.046	27.403	.000	.566
Elaboration	18.218	18.218	7.592	.012	.266
Originality	209.299	209.299	13.620	.001	.393

4) The effect of learning activity to improve Originality Ability of Students: The fourth analysis for originality; this analysis was aimed at finding out whether there are differences in the making of stories and concretizing activities based on robotics learning originality ability of students before and after the intervention. Research Question 4: Is there a difference in the mean values of students' originality ability between before and after the intervention? paired-samples t-test for students' originality ability shown in Table 1. The sig (2-tailed) score .000 means $P<0.05$, there is also a significant difference between the mean student originality score before and after the intervention, and the effect size of the ability originality ability shown in Table 2. ($\eta p^2 = .393$), it means that the effect size of the RL to increase the ability of originality is 39.3%.

Based on the paired sample t-test analysis, the implementation of the RL shows that there were significant differences in the mean score between post-test and pre-test, where the mean value of the post-test was higher than the mean score of the pre-test on all variables of FC (elaboration, flexibility, fluency, and originality). Furthermore, based on ANOVA analysis, the use of RL has a growing impact on all FC variables (fluency = 60.9%, flexibility=56.6%, elaboration = 26.6%, originality =39.3%). The results of this study showed that the robotic learning activity effectively improves all figural creativity variables. The results revealed consistency with another research following the study conducted by Masril *et al.* [1] showed that learning activity (introduction of robotic technology, creating a robot, and developing a robot) can improve students' creativity. Burhans showed that learning activities (introduction of robotic technology, discussion, creating a robot) could improve students' creativity [39]. Sullivan showed that robotic design, programming, and play with robotic kits were activities with a strong potential to enable student creativity [40]. Another study conducted by Badeleh [16] showed that Robotics training (presentation, discussion, built robot, collaboration) could influence and improve creativity and learning in physics. The result of this study could be a consideration to lead to a better understanding of the importance of learning activities design that was relevant to the learning objectives in the teaching-learning process.

IV. CONCLUSIONS

The new learning activity consists of some activities: imagination, discussion, competition to stimulate fluency ability; modification, negation to stimulate flexibility; making stories, concretizing to stimulate elaboration ability; new creation, different answers to stimulate originality ability. The effectiveness of this new learning activity can improve students' figural creativity variables, such as flexibility, fluency, elaboration, and originality. This study's implication was contributing reference in robotic learning. The real effect of the implementation of learning activities has been shown, so this study suggests schools develop learning materials, learning methods, and learning models that can stimulate FC variables in students based on robotic technology.

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