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The Impact of Using Learning Media Robot Transporter toward Learning Outcome and Learning Gain of Students

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Abstract. *This study aims 1) to determine the validity and reliability of the robot transporter learning media instrument, 2) to know the differences in the student learning outcomes between the use of robot transporter and PowerPoint as learning media, and 3) to know how much the learning gain score from the use of these two media. A pre-test-post-test comparison group design type was used. A sample of 60 vocational students participated in two groups, the experimental group (N = 30) and the control group (N = 30). The results show that the robot transporter learning media is categorized as valid and reliable. The t-test result is 12.589 greater than the t table, namely 2.3596 with a significance of 0.05. Therefore, there is a difference in student learning outcomes. The mean of learning gain score on the robot transporter is 0.694, higher than the mean of learning gain score on the PowerPoint which is 0.289. The use of robot transporter as learning media can help students to be more interactively involved in learning. This is indicated by the students' post-test scores and the value of the gain learning in the experimental class was higher than the control class.*

Keywords: *Robot transporter; Gain learning; Microcontroller; Learning outcome; Learning media*

INTRO DUCTION

Robot use has been widely used in many aspects, such as in the military (Ha et al., 2019), industry (Gadaleta et al., 2019), and medical (Zhang et al., 2017). Likewise in the field of education, robots have also been widely used to help students in teaching and learning process. Robots can be used as a learning medium for the learning process in the classroom. The use of robots in the learning process can help improve understanding of learning material (Breuch & Fislake, 2019). Robots have been widely applied in the field of education by assisting in learning materials such as STEM (Kim et al., 2015), cyber-physical systems (Crenshaw, 2013), programming (Ohnishi et al., 2017). Robots used in education have advantages; for example, robots can be implemented in learning models such as problem-based or project-based learning models. The use of robots as a learning medium in these learning models is because robots have the flexibility to be implemented in the learning process (Barak & Assal, 2018).

SMK Al Khairiyah, a vocational high school in Bangkalan - Indonesia has problems with Microcontroller learning. Students have a lot of difficulties understanding the microcontroller material so that it affects student learning outcomes. One of the complaints from students is the lack of learning media that can support microcontroller subjects. Besides, learning that has been taking place is only presented in one direction without involving students in learning activities directly, students are not actively involved in interacting with learning media.

Therefore, the robot used as a learning medium is expected to be able to help improve students' understanding of the microcontroller material. This is supported by research (Gorakhnath, 2018) which states that the use of robots as a learning medium can help students be active in learning because students can be directly involved with the media. Robots can be used in education because they can improve learning outcomes (Athanasiou et al., 2019). As it is known that the Basic Competitions to be able to understand Microcontroller subjects are as follows to make simple application programs and to demonstrate the program. Therefore, the robot is very suitable to be used as a learning medium. This is because a robot is mostly composed of electronic devices such as microcontrollers and to control the movement of the robot, programming via the microcontroller is required. Therefore, using a robot can help students to be directly involved in programming so that they can directly apply the material from the microcontroller (Noguchi et al., 2017).

The selection of a robot as a learning medium for microcontroller material is considered appropriate. The robot can be used as a learning medium in the learning material of engineering or technology (Patino et al., 2014). This is supported by researchers (Bacca-Cortes et al., 2017) which state that the use of robot media is an alternative that needs to be developed to teach students to learn computer programming. This research examined the use of robotic learning media in microcontroller subjects and measured how much gain learning of students that using robot transporter as learning media and analyzing student learning outcome that using robot transporter learning media.

The novelty of this research is in the form of developing testing instruments (pre-test and post-test). The material testing instruments are based on a robot transporter. With these testing instruments, students are tested with exam material such as the components that make up the transporter robot, to learn the functions and the workings of these components, and how to assemble these components so that they can work according to the given computer programming. Therefore, this robot transporter learning media is different from other research which only tests the robot programming without testing the students' basic abilities towards understanding and mastery of the components that make up the transporter robot and the work functions of the transporter robot. Students' basic mastery of the components that make up the transporter robot, scientifically it can cause students to understand those components are made of what kind of materials. Meanwhile, students' mastery of the work function of the robot transporter means that students can scientifically know and apply the theorems of physics and mathematics to move the robot transporter in a specified direction or manner.

From the description above, this study aims 1) to find out the validity and the reliability of testing instruments based on robotic learning media, 2) to compare student learning outcomes using robot learning media whether it is better than students using learning media using PowerPoint 3) to find out how much gain learning from the use of the two media.

METHOD

This research used an experimental design with a pre-test-post-test comparison group design type. A pretest-posttest comparison group design is done by comparing the conditions before and after using a learning media (before-after) or by comparing it with groups that continue to use conventional learning. This design aims to allow the researchers to evaluate the new treatment relative to the previously used treatment (Gliner, J. A., Morgan, G. A., & Harmon, 2003). This research used an experimental group, a class that used the robot transporter learning media, and the control group, a class that used PowerPoint learning media.

The research subjects were the students of SMK Al Kholiliyah, a vocational high school in Bangkalan Indonesia. The total number of students in the Department of Industrial Electronics Engineering at SMK Al Kholiliyah for class XII there are 80 students. The samples were randomly selected from several students majoring in Industrial Electronics Engineering. The selection was random and did not differentiate between class and sex in sampling.

The experimental class consisted of 30 participants and the control class consisted of 30 participants.

The initial procedure was carried out by carrying out the validity test and the reliability test of the research instrument before data collection was carried out in the classroom. By using the pretest-posttest comparison group design, the research procedure was to form two classes, the experimental class, and the control class. In both classes, a pretest was carried out to measure students' initial cognitive learning outcomes.

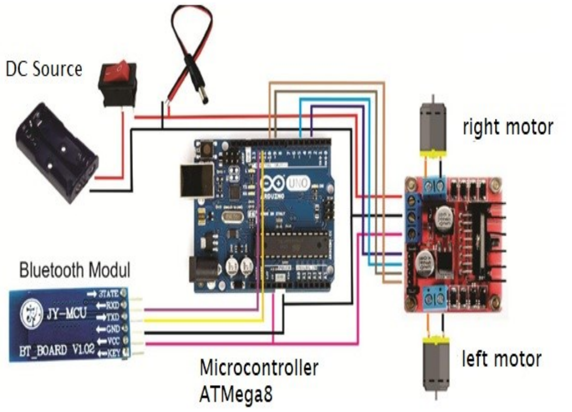

Figure 1. Supporting components for the Robot transporter

The learning model carried out for these two classes was to use the direct learning model. In the next procedure was in the experimental class an intervention is carried out by teaching the microcontroller material using the robot transporter learning media, while the control class is carried out by the intervention by teaching the microcontroller material using the PowerPoint learning media. After completing the different interventions carried out, the next procedure is to do a posttest to determine the student's cognitive learning outcomes. The final stage is to analyze student learning outcomes and how big the learning gain score is obtained from the two classes.

This research uses robot learning media with the type of robot transporter. This robot transporter consists of several parts, including Android Smartphone, DC Source, ATMega Microcontroller, Bluetooth Module, and servo motor. Figure 1 shows the constituent components of the robot transporter. ATMega microcontroller is the main part that can be used to study microcontroller subjects.

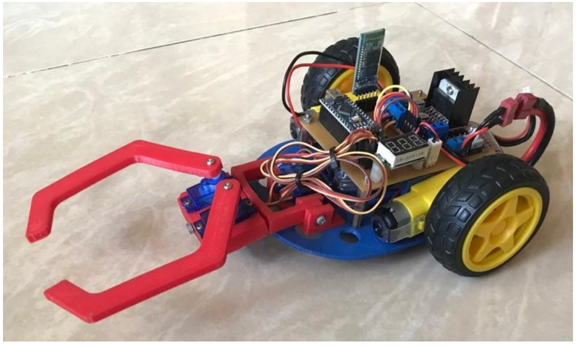

Figure 2. The performance of the robot transporter

Figure 2 shows a robot transporter that has been assembled from its constituent components. Students learn to program the ATMega8 Microcontroller so that the robot transporter can communicate or connect between Android Smartphone and Bluetooth so that the robot transporter can be moved manually via an Android Smartphone.

Research instruments include a) Instrument Validity and Reliability Test, b) multiple-choice questions that have been validated by experts for pre-test and post-test.

The data collection technique used in this study was to use a questionnaire instrument and pre-test and post-test questions in the form of multiple-choice test questions that have been validated by experts. The test was carried out twice, namely before learning (pretest) and after learning (posttest). The pre-test is used to determine students' initial understanding of learning microcontroller programming. The post-test is used to determine the students' final understanding of microcontroller programming.

The control class and experimental class were given the same test treatment namely pretest and posttest questions. Then the results of the pretest and posttest were compared between the control and experimental classes using the t-test analysis. The t-test was used to determine the learning outcomes using the robot transporter learning media, whether there is any difference with the learning outcomes using PowerPoint learning media. Furthermore, the results of the pretest and posttest can be used to calculate the gain learning score.

Question Instrument Validity. A question is declared valid if in a calculation with a significance level (α), the value of $r_{count} > r_{table}$ then the question is declared valid, whereas if the value of $r_{count} < r_{table}$ then the question is declared invalid.

Reliability. Reliability refers to the understanding that an instrument can be trusted to be used as a data collection tool if the instrument is good. This study uses the reliability criteria which refer to the reliability criteria used by (Ratumanan, T., & Laurens, 2011). The table below shows the instrument reliability criteria.

Table 1. The Instrument Reliability Criteria

Reliability Coefficient	**Criteria**
$0,80 \leq r$	High Reliability
$0,40 \leq r < 0,80$	Intermediate Reliability
$r < 0,80$	Low Reliability

T-test

The learning outcomes obtained through the post-test in the experimental class and control class were carried out by the T-test to answer the hypothesis, whether there is any difference in student learning outcomes using robot transporter learning media toward student learning outcomes using PowerPoint learning media.

Gain Learning Score. Hake (2002) introduced the mean gain that denoted <gain> for a class of students who were given a pretest and a post-test. The formula of the mean gain is as follow: <gain> = (mean post-test % – mean pre-test %) / (100% - mean pre-test %)

For individual gain, (McGowen & Gary, 2014) used the formula as follow: gain = (final-test% - initial-test%)/(100% - initial-test%)

RESULT AND DISCUSSION

The Cognitive Item Validity Test Results

The validity test of this item is carried out on the questions for the pretest and posttest which functions to determine the success of using the robot transporter learning media in microcontroller subjects.

This validity test was conducted on a group of 30 students who had passed the microcontroller programming subject. Cognitive items for microcontroller lessons are 40 items. The results of the validity of the items can be seen in Table 2.

The Cognitive Question Item Reliability Test Results

A reliability test is a test conducted to measure the level of consistency of the score used when the test is repeated. The results of the instrument reliability test are shown in Table 3 as follows:

Table 3. Cognitive Question Item Reliability Test Results

Cronbach's Alpha	N of Items
0.983	40

Based on the results obtained, it can be seen that r_{count} is 0.983, so that with the rule of decision $r_{count} > r_{table}$, the question is declared reliable, whereas if $r_{count} < r_{table}$, then the question is not reliable. Based on the data in table 3, it can be obtained r_{count} (0.983)> r_{table} (0.361), so the test instrument is declared very reliable if it refers to Table 1.

Assessment of Learning Outcomes in the Cognitive Domain

The results of the cognitive domain assessment were obtained through pre-test and post-test with 40 items of multiple-choice questions. The testing was to test the control class with 30 students and the experimental class with 30 students. In the control class, the mean pre-test score was 43.3 and the post-test mean score was 59.7. The difference in the average value between the pre-test and post-test is 16.4. Whereas in the experimental class the pre-test means the score was 48.57 and the post-test average score was 84.27. The difference in the average value between the pre-test and post-test is 35.7. This shows that the difference in the mean value of pre-test and post-test in the experimental class is greater than the control class. By using the learning gain formula on research (Hake, 2002), the learning gain results show that learning by using robotic media transporter has a higher learning gain is 0.69 compared to gain classroom learning by using PowerPoint, learning gain is 0.29.

Student Learning Outcomes in the Cognitive Domain in terms of Learning Media

H_0: student learning outcomes in the cognitive domain who learn using robot transporter-based learning media, there is no difference with students who learn using PowerPoint.

H_1: the learning outcomes of students in the cognitive domain who learn using robot transporter-based learning media, there is a significant difference compared to students who learn using PowerPoint.

The results of the analysis of student learning in the cognitive domain in terms of learning media can be seen in Table 5. Table 5 shows that the t-test value of 12.589 shows that it is greater than the t-table, which is 2.3596, which means reject H0 and accept H1. Likewise, Sig. (2-tailed) value of 0.000, this shows a significance value of 0,000 which is smaller than 0.05 (Sig <0.05), which means reject H_0 and accept H_1. Therefore, it can be concluded that the cognitive learning outcomes for students who learn using robot transporter learning media, there are significantly different compared to students who learn using PowerPoint.

Discussion

This research developed a testing instrument for pretest and posttest in learning robot transporter as part of the learning material of microcontroller. This instrument measures students' cognitive abilities towards the introduction of the components of the transporter robot, the function of each component of the transporter robot, and the microcontroller programming to move the wheels and grippers of the transporter robot. The learning intervention was using a transporter robot as a learning medium. The results showed that students using the transporter robot learning media intervention were better than using PowerPoint. The learning material for the testing instrument is used not only for robot programming but also to determine the components of the transporter robot and its functions. This is different from research conducted by (Noguchi et al., 2017), (Bacca-Cortes et al., 2017), and (Karaahmetoğlu & Korkmaz, 2019) which only focuses on programming.

Learning using a robot transporter can provide better cognitive knowledge because students can directly interact with the media. This is due to students' curiosity and interest in learning robots. Student involvement also influences motivation to learn more about transformer robots. Research conducted by (Athanasiou et al., 2019) and (Chou, 2018) (2018) also states that learning interventions using robots can improve student learning outcomes. Students in building a transporter robot can learn the technology and science used. For example, when students build a robot transporter, they must be able to recognize and understand each component of the robot transporter. The components of the robot transporter include wheels, grippers, batteries, communication modules, and a microcontroller. To move the robot electronically, students must learn the working principles of the DC motor used. Meanwhile, scientifically, to learn the working principle of a DC motor, students must learn the concepts of physics related to the laws of motion and the laws of magnetism. In the gripper component, to move the claws, students use their knowledge of science and technology to know and understand the power of the gripper to able to pick up the items. In the process of moving the gripper, the concepts and laws of physics can be applied such as the law of current in determining how much current is needed so that the gripper is strong enough and Newton's law to determine the mechanical motion of the gripper. This is in line with Noguchi et al., (2017) research's that robots can be used as a tool in studying motion robots as well as research by Liao et al., (2016) on the concept of robot mechanical work.

As for programming so that the clamp of the gripper is strong enough, it is necessary to have a good understanding of programming techniques. This is equivalent to the research conducted by Bacca-Cortes et al., (2017) that basic programming mastery can be trained by using a mobile robot to train students to be able to move a mobile robot according to what they write on computer programming. The use of batteries to supply all electronic components can be used by students in learning the concept of flowing current. Students can determine the damage if an electronic component does not work, and then students can learn about troubleshooting the transport robot. In line with research conducted by Barak & Assal, (2018), Karaahmetoğlu & Korkmaz, (2019) and Kim et al., (2015) stated that robot learning can be used for students learning material related to STEM (Science, Technology, Engineering, Math).

Table 2. The Cognitive Item Validity Test Results

No Item	r_{count}	r_{table}	Category	No Item	r_{count}	r_{table}	Category
1	0.741	0.361	Valid	21	0.496	0.361	Valid
2	0.906	0.361	Valid	22	0.906	0.361	Valid
3	0.847	0.361	Valid	23	0.906	0.361	Valid
4	0.847	0.361	Valid	24	0.724	0.361	Valid
5	0.724	0.361	Valid	25	0.724	0.361	Valid
6	0.906	0.361	Valid	26	0.421	0.361	Valid
7	0.724	0.361	Valid	27	0.906	0.361	Valid
8	0.906	0.361	Valid	28	0.906	0.361	Valid
9	0.906	0.361	Valid	29	0.765	0.361	Valid
10	0.724	0.361	Valid	30	0.906	0.361	Valid
11	0.765	0.361	Valid	31	0.724	0.361	Valid
12	0.906	0.361	Valid	32	0.853	0.361	Valid
13	0.724	0.361	Valid	33	0.853	0.361	Valid
14	0.906	0.361	Valid	34	0.480	0.361	Valid
15	0.906	0.361	Valid	35	0.724	0.361	Valid
16	0.724	0.361	Valid	36	0.853	0.361	Valid
17	0.906	0.361	Valid	37	0.724	0.361	Valid
18	0.765	0.361	Valid	38	0.514	0.361	Valid
19	0.724	0.361	Valid	39	0.853	0.361	Valid
20	0.432	0.361	Valid	40	0.906	0.361	Valid

Table 4. Assessment of Learning Outcomes in the Cognitive Domain

Student ID	Control Class		Individual Gain	Student ID	Experiment Class		Individual Gain
	pre-test	post-test			pre-test	post-test	
K1	48	65	0.33	E1	65	88	0.66
K2	45	63	0.33	E2	70	95	0.83
K3	40	55	0.25	E3	65	85	0.57
K4	48	65	0.33	E4	45	78	0.60
K5	33	48	0.22	E5	55	93	0.84
K6	30	55	0.36	E6	50	90	0.80
K7	48	65	0.33	E7	48	95	0.90
K8	40	55	0.25	E8	43	80	0.65
K9	48	65	0.33	E9	58	83	0.60
K10	60	78	0.45	E10	63	88	0.68
K11	45	63	0.33	E11	65	88	0.66
K12	48	63	0.29	E12	58	88	0.71
K13	48	63	0.29	E13	43	78	0.61
K14	48	63	0.29	E14	43	85	0.74
K15	35	50	0.23	E15	45	78	0.60
K16	35	50	0.23	E16	53	80	0.57
K17	43	58	0.26	E17	43	93	0.88
K18	58	78	0.48	E18	50	95	0.90
K19	45	60	0.27	E19	40	78	0.63
K20	58	78	0.48	E20	30	85	0.79

Student ID	Control Class pre-test	post-test	Individual Gain	Student ID	Experiment Class pre-test	post-test	Individual Gain
K21	45	60	0.27	E21	45	90	0.82
K22	45	60	0.27	E22	38	78	0.65
K23	45	60	0.27	E23	40	75	0.58
K24	43	58	0.26	E24	40	75	0.58
K25	38	53	0.24	E25	43	75	0.56
K26	45	60	0.27	E26	43	88	0.79
K27	35	50	0.23	E27	50	88	0.76
K28	25	45	0.27	E28	40	83	0.72
K29	40	55	0.25	E29	48	78	0.58
K30	35	50	0.23	E30	38	75	0.60
Average	43.3	59.7	0.29	Average	48.57	84.27	0.69
Learning Gain		0.29		Learning Gain		0.69	

Table 5. Results of Student Learning Hypotheses in the Cognitive Domain

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Learning Result	Equal variances assumed	0.236	0.629	-12.598	58	0.000	-24.56667	1.95000	-28.47001	-20.66332
	Equal variances not assumed			-12.598	55.001	0.000	-24.56667	1.95000	-28.47455	-20.65879

CONCLUTION AND SUGGESTION

The use of robot transporters as learning media in microcontroller subjects can help students to be more interactively involved in microcontroller learning. The students' interest in using the robot transporter learning media can spur their understanding of the material given. This is indicated by the value of the gain learning in the experimental class is higher than the control class. Likewise, the students' post-test scores in the experimental class were higher than the control class. The development of the robot transporter learning media is expected to be used to train the psychomotor skills of vocational school students. This is because vocational students are more focused on mastering the skills needed in the world of work.

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