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Effectiveness of Android-Based Waterwheel Teaching Aid to Improve Students' Critical Thinking Skills

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Abstract

A study has been carried out on android-based waterwheel props used for dynamic fluid learning. The aim is to increase skills of critical thinking of students. The research subjects were 22 students of the sixth semester of Physics Education Study Program, Faculty of Teacher Training and Education, Muhammadiyah University of Purworejo. The implementation of the research is: before learning students are given a pretest of skills of critical thinking, then learning is carried out using an android-based waterwheel prop, then given a posttest with questions that weigh the same as the pretest questions. Furthermore, n-gain was calculated from the pretest-posttest tests of critical thinking skills, and analyzed by parametric and/or non-parametric analysis of statistical. The results of this study is a significant increase in skills of critical thinking at the 5% significance level with an average n-gain greater than 0.7 which means in the high category, and the Anova test produces a Sig score. of 0.342 which means it is greater than the probability score of 0.05 so that Anova test results show that there are similarities in the improvement of skills of critical thinking in the two learning meetings.

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1. Introduction

In this industrial era 4.0, various ways are carried out to improve learning that can support 21st century skills. One of them is critical thinking skills. Those who do not focus on critical thinking skills will have difficulty facing future challenges [1]. Skills of critical thinking are very important to be trained because they are needed in everyday life to get quality human resources [2]. Critical thinking skills are thinking activities that involve such as analyzing, synthesizing, making judgments, creating and applying new knowledge in the real world [3]. Based on this definition, this thinking skills requires students to formulate problems, make hypotheses, conduct experiments and conclude to gain new knowledge [4]. Indicators of critical thinking skills according to this definition are analyzing (C4), evaluating (C5), and creating (C6) [5].

This critical thinking skills demands special attention because so far the skills of critical thinking of Indonesian students are still low. Research from the Program for International Assessment [6] shows that Indonesia's literacy score is 382 and is ranked 64th out of 65 countries. In the field, it is known that there are problems in terms of learning in schools, where many schools tend to have informative

learning processes and only emphasize the formulation of mathematical quantities of physics. Moreover, physics learning, which should be more practical, is not done by the teacher. Even if it is done, it is more demonstrative with one tool or simulation with a computer program so that the knowledge that reaches students is still abstract.

In some universities that have physics or science education programs there is also not much difference in terms of learning at school. For example, in Physics Education Study Program, Faculty of Teacher Training and Education, Muhammadiyah University of Purworejo, due to the lack of facilities and infrastructure for practicum, the lecture process is carried out more in theory and less emphasis on practicum. As a result, the purpose of lectures so that students can increase their skills of critical thinking is not as expected. Therefore, it takes creativity from lecturers and students to make practical tools that support the continuity of the lecture process that is able to lead students to achieve increased skills of critical thinking,

One of the lecture facilities to increase skills of critical thinking is learning by using android-based waterwheel props. The android-based waterwheel is an innovation prop to overcome the limitations of practical tools in schools while taking advantage of advances in information technology [7] [8]. The schematic of the waterwheel teaching aid is shown in Figure 1.

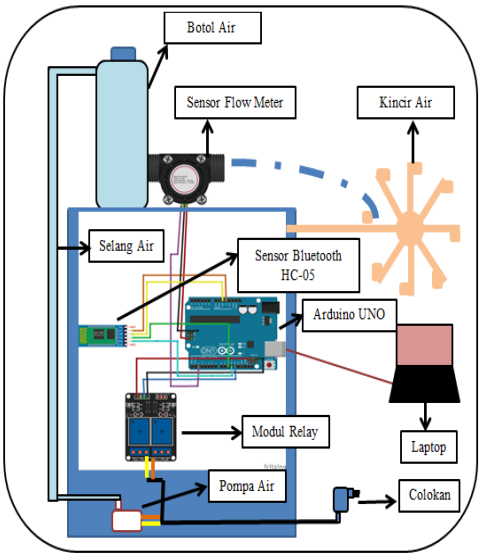

Figure 1. Schematic of Android-Based Waterwheel Teaching Aid

This tool is used for learning with dynamic fluid subjects and has been validated and declared to be very valid and reliable. Based on a limited test to see the implementation of LP, it has also been declared very practical for the learning process [8]. Therefore, the next task is to apply android-based waterwheel teaching aid to achieve learning instructional goals. The instructional purpose is to increase skills of critical thinking.

The main problem of this research is how effective the android-based waterwheel props used for dynamic fluid learning are in increasing skills of critical thinking of students. Effective to increasing skills of critical thinkings of students if when the waterwheel props are used for learning it can improve skills of critical thinking at least 50% of the number of students who have low skills of critical thinking [9] [10].

2. Method

This study used the subject of 22 students ini sixth semester of 2019-2020 academic year in Physics Education Study Program, Faculty of Teacher Training and Education, Muhammadiyah University of Purworejo. The research was conducted on the subject of fluid dynamics which is the subject matter of the Physics 2 SMA course.

To see the effectiveness of the android-based waterwheel prop to improve critical thinking skills, starting with a pretest by distributing critical thinking skills test questions with indicators of analyzing (C4), evaluating (C5), creating (C6) [11]. The pretest was conducted online with the help of Google Forms and Google Classroom. After the pretest, learning was carried out using an Android-based waterwheel props online with lesson plan (LP) learning tools and student worksheets. After completing the learning, a posttest with the same weight as the pre-test was carried out, and it was carried out online with the help of Google Forms and Google Classroom. This research was conducted in two online meetings with LP 1 and LP 2 learning tools.

This study uses effectiveness data, with the effectiveness instrument using a pretest-postet test of skills of critical thinking, then analyzed by paired *t-test* at a significance level of 5%. The improvement of critical thinking skills can be known by conducting *N-gain* analysis, where *N-gain* = (posttest score-pretest score)/(maximum score-pretest score), where *N-gain* = (posttest score-pretest score)/(maximum score- pretest score), with the criteria of *N-gain* < 0.3 (low), 0 .3 ≤ *N-gain* ≤ 0.7 (medium), and *N-gain* > 0.7 (high) [9].

3. Result and Discussion

The effectiveness of learning with waterwheel teaching aid in this trial is to increse skills of critical thinking of students. To get skills of critical thinking data is by taking pretest scores and posttest scores of skills of critical thinking. Data of skills of critical thinking were obtained through pretest-posttest skills of critical thinking while the pretest-posttest data for skills of critical thinking can be seen in **Error! Reference source not found.** and **Error! Reference source not found.**.

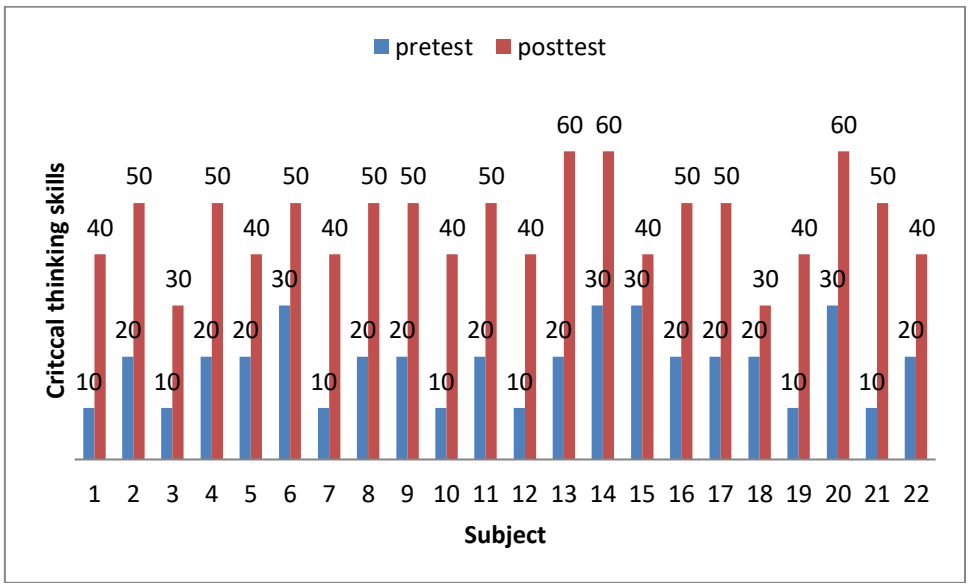

Figure 2. Score of Pretest-Posttest Critical Thinking Skills (1)

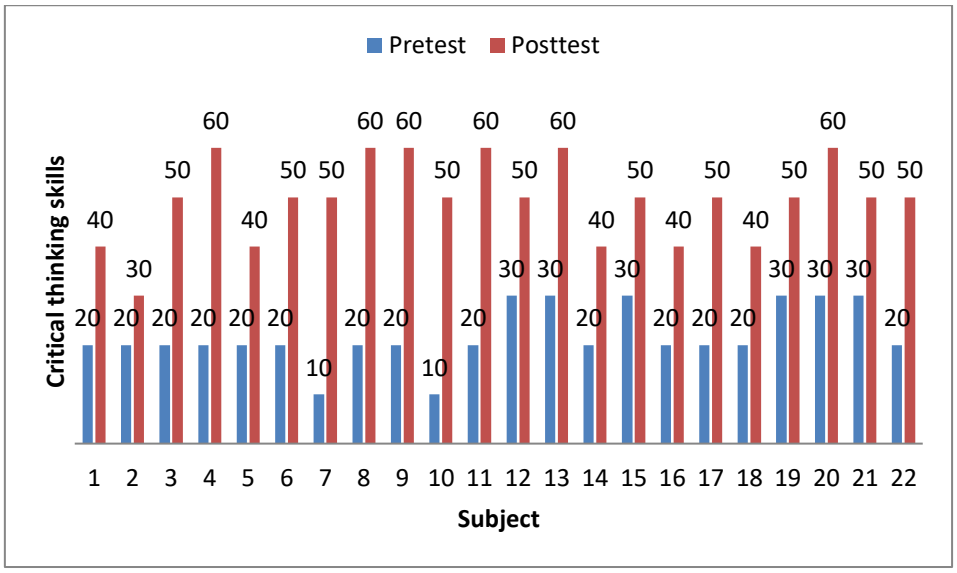

Figure 3. Score of Pretest-Posttest Critical Thinking Skills (2)

Pretest-posttest function to see the effectiveness of android-based waterwheel props in increasing critical thinking skills. If the posttest results are better than the pretest results, it means that the android-based waterwheel props are effective for increasing critical thinking skills of students. But if the posttest results are no different from the pretest results or even lower than the pretest, it means that the android-based waterwheel props are not effective for increasing skills of critical thinking of students. **Error! Reference source not found.** and **Error! Reference source not found.** show that there is a difference between the posttest and the pretest, where the posttest result is greater than the pretest result. This means that there is an increase in skills of critical thinking of students. The difference between the results of the pretest and the posttest is called the *N-gain*, which serves to see the increase in skills of critical thinking after learning with android-based waterwheel teaching aid. The next step is to do a paired sample *t-test* with the requirements that the data of pretest-posttest must be normally distributed and homogeneous. Calculation of normality with the Kolmogorov-Smirnov test and homogeneity with the Levene Test [12] [13]. The normality test result is in **Error! Reference source not found.**, while the the homogeneity test result is in **Error! Reference source not found.**.

Table 1. The Results of Normality Test

N	Mean	Std. Deviation	Asymp.Sig (2-tailed)
88	33.98	15.796	.000

Table 2. The Results of Homogeneity Test

N	df1	df2	Sig (2-tailed)
88	1	86	.853

Error! Reference source not found. shows that the significance value of Asymp sig. (2-tailed) of 0.000 less than 0.05. the conclusion of the Kolmogorov-Smirnov normality test is that the pretest-posttest data on students' critical thinking skills are not normally distributed. Meanwhile, **Error! Reference source not found.** shows that the significance value (sig.) of the pretest-posttest data of students' critical thinking skills is 0.850. Because the value of 0.850 is greater than 0.05, it is concluded that the variance of the posttest-pretest data is the same or homogeneous. Because it is not normally distributed, the data analysis used to see whether there is a difference between the pretest data and the posttest data of student's critical thinking is non-parametric statistics using the Wilcoxon test [14].

The Wilcoxon test show provides information that Asymp.sig (2-tailed) is 0.000 which means it is less than 0.05. This means that there is a significant difference between the pretest data and the posttest data of skills of critical thinking of students, which means that there is an effect of using waterwheel to increase student critical thinking.

Furthermore, to find out whether there is a difference in the increase critical thinking at each meeting, the *N-gain* data analysis of critical thinking is carried out. Learning outcomes using waterwheel teaching aid at the 1st and 2nd meetings get *N-gain* data that varies from low, medium, and high. However, if it is averaged, it will produce an *N-gain* data of 0.72. The *N-gain* means it is above 0.7, which means it is in the high category kategori. The next step is to perform statistical calculations to test the similarity of increasing skills of critical thinking at each meeting by analyzing the *N-gain* data analysis of skills of critical thinking test with Anova test [15]. Anova test requirements are *N-gain* data must be normally distributed and homogeneously distributed.

The significance value of Asymp sig. (2-tailed) of 0.152 for the 1st meeting and 0.93 for the 2nd meeting, because both are greater than 0.05, it is concluded that the data on the *N-gain* test of skills of critical thinking of students are normally distributed. Meanwhile, the significance value (sig.) of the *N-gain* data on the critical thinking skills test of students are 0.690. Because the value of 0.690 is greater than 0.05, it is concluded that the variance of the *N-gain* data is the same or homogeneous. The next step is to carry out the Anova test to calculate the *N-gain* data for skills of critical thinking tests. This Anova test was conducted to determine whether there was a difference in the increase in skills of critical thinking at the 1st meeting and 2nd meeting [15]. **Error! Reference source not found.** is the result of the calculation of the Anova test.

Table 3. Anova Test Results of Studeng Critical Thinking Skills

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	,039	1	,039	,923	,342
Within Groups	1,793	42	,043		
Total	1,832	43			

Error! Reference source not found. it is known that Sig. of 0.342 which means it is greater than the probability value of 0.05. Therefore, as the basis for making Anova test decisions, then "Ha is rejected". Which means there is no difference in *N-gain* test of skills of critical thinking between the 1st meeting and the 2nd meeting. Skills of critical thinking indicators, namely analyzing (C4), evaluating (C5), and creating (C6) are shown in Figure 4.

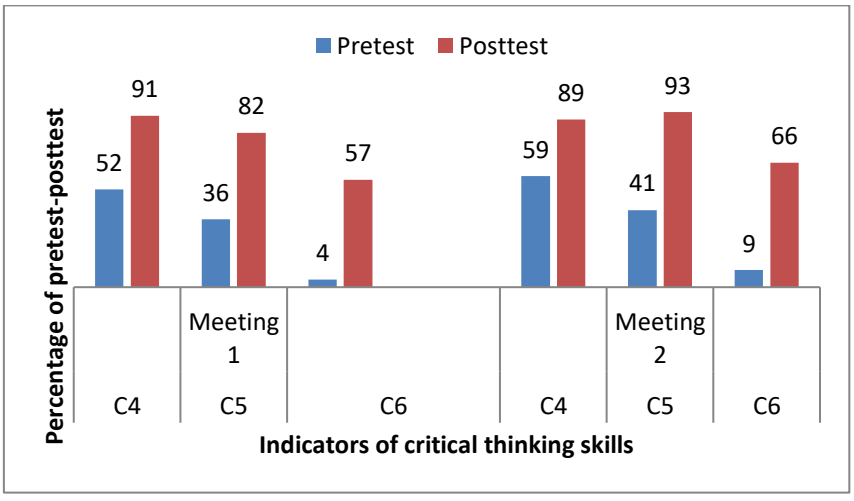

Figure 4. Students' Critical Thinking Skills Achievement

From Figure 4 shows that the pretest for the 1st meeting the correct answer for C4 is 52%, C5 is 36%, C6 is 4% and for the 2nd meeting the correct answer for C4 is 59%, C5 is 41%, C6 is 9 %. While the posttest for the 1st meeting the correct answers for C4 were 91%, C5 was 82%, C6 was 57%, and for the 2nd meeting the correct answers for C4 were 89%, C5 was 93%, C6 was 66%. The purpose of this research is the use of android-based waterwheel props in dynamic fluid learning to increase skills of critical thinking of students. This android-based waterwheel prop is designed in such a way that its operation is quite simple, namely by simply bringing the android-based smartphone to the user's face and then saying "HIDUP" then the wheel will turn on, and if you say "MATI", then the wheel will turn off (Figure 1)[8-16]. This waterwheel teaching aid for dynamic fluid learning is used in two meetings. At each meeting a pretest and posttest were conducted, which served to see the effectiveness of the teaching aids in improving critical thinking skills. Figure 2 and Figure 3 show that the pretest score is always lower than the posttest score with n-gain mostly in the medium ($0.3 \leq N\text{-}gain \leq 0.7$) and high ($N\text{-}gain > 0.7$) categories, and only 1 case is in the low category ($N\text{-}gain < 0.3$) at the 1st meeting and 2nd meeting. This shows that in every learning there is always an increase in critical thinking skills [4-17].

The paired sample *t-test*/Wicoxon results which indicates that the use of android-based waterwheel teaching aid has a significant impact on increase skills of critical thinking of students because there is an impression of real experience in using the tool [18]. This is supported by the *N-gain* of critical thinking skills test of each student (Figure 4), most of which are in the medium and high categories, and only one student is in the low category at each meeting.

The results of the Anova test (Table 3) show that the use of android-based waterwheel teaching aid on the subject of fluid dynamics does not significantly increase skills of critical thinking of students between the 1st and 2nd meetings. In other words, there are similarities in the increasing of skills of critical thinking significantly between the 1st and 2nd meetings of these students. The critical thinking skills in this study with indicators of analyzing (C4), evaluating (C5), creating (C6) (Figure 4), where skills of critical thinking of students are graded according to the levels in Bloom's Taxonomy [5] [19][20].

Bloom's Taxonomy can be used as a guide for teachers in preparing evaluation questions related to skills of critical thinking. General guidelines are questions compiled based on the lowest level of thinking, namely analyzing (C4) then evaluating (C5) and finally creating (C6) [21]. In this way, teachers can find out which cognitive domains have been achieved by students, as well as be able to develop strategies to improve the abilities of students who still have a low level of cognitive domain. The effectiveness of the android-based waterwheel teaching aid in dynamic fluid learning to improve skills of critical thinking is also supported by the observations of lecturers and student activities during the learning process. Observation of the implementation of learning with waterwheel props is going well, android-based waterwheel props can be operated as expected. This shows that the android-based waterwheel teaching aid is effective for improving students' critical thinking skills on the subject of dynamic fluid. However, the improvement of critical thinking skills is not only influenced by one variable, namely android-based waterwheel props, but is influenced by many factors such as intelligence, psychology, and the learning environment [22-23]. Therefore, teachers in carrying out learning must also pay attention to these factors, so that the improvement of student critical thinking skills.

4. Conclusion

The conclusion is that the android-based waterwheel prop used for dynamic fluid learning can significantly improve skills of critical thinking of students with a significance level of 5% with an average *N-gain* greater than 0.7 which means an increase in skills of critical thinking on high criteria. In addition, the Anova test produces a Sig score. of 0.342 which means it is greater than the probability score of 0.05, which means that there are similarities in the improvement of skills of critical thinking in the two learning meetings. Research related to these teaching aids can be developed for other physics materials, with the aim of overcoming the limitations of physics practicum tools. In addition, other benefits are also obtained, namely increasing the creativity of teachers/prospective teachers in carrying out the physics learning process.

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