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The Effectiveness of Physics Mobile Learning (PML) with HomboBatu theme to Improve the Ability of Diagram Representation and Critical Thinking of Senior High School Students

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This study aimed to determine the effectiveness of Physics Mobile Learning (PML) with HomboBatu theme smartphone Android-Assisted to improve the ability of diagram representation and critical thinking of students of Grade X in senior high school. The research type used was experimental research with pretest-posttest control group design. The sampling technique selection used cluster random sampling. The subjects were 32 students of Grade X MIPA 4, SMAN 6 Yogyakarta as control class with learning treatment of Powerpoint media and 22 students of Grade X MIPA 7, SMAN 6 Yogyakarta as experimental class with learning treatment of PML smartphone Android-Assisted with BatuHombo theme. Test instruments consisted of pretest and posttest. Data analysis used was analysis of N-Gain and Hotteling's Trace multivariate test (MANOVA). The results showed that learning with PML-themed HomboBatu media was more effective in increasing the representation ability of N-Gain diagrams by 0.78 in the high category. However, there was no significant difference in N-Gain scores in the experimental class and control class in improving critical thinking skills. This Physics Mobile Learning can be used by students or teachers to study Indonesian culture (Nias) for its learning media as well as for learning experiences that train the ability of diagram representation and critical thinking.

Keywords: physics mobile learning, HomboBatu, diagram representation, critical thinking, learning

INTRODUCTION

Ability of representation and critical thinking is a way to solve a problem in physics learning (Docktor&Mestre, 2014). The use and selection of appropriate representation formats can improve students' performance and provide access to obtain knowledge that

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is more complete (Fredlund, Linder, Airey, & Linder, 2014), making it easier for students to understand physical problems and also to provide guidance and instruction in solving physical problems (Docktor&Mestre, 2014; Kohl & Finkelstein, 2005; Tuminaro & Redish, 2007). Students who are able to draw free body diagrams correctly are more able to accurately solve the Physics problem (Larkin & Simon, 2009; Rosengrant, Van Heuvelen, &Etkina, 2005). Diagram representation is needed by students in solving the physics problems because the characteristics of physics are explained visually, such as using a force diagram or motion diagrams.

Students' critical thinking ability becomes a necessity and a process of thinking for problem solving in everyday life (De Cock, 2012; Masek & Yamin, 2011). Rusipal (2011) states that physics subjects can train students' critical thinking processes in problem solving. Research by Nurohman, Ashari, and Nurhidayati (2014), and by Pratama and Istiyono (2015) revealed that students' thinking ability has not been optimally developed through the process of Physics learning. This learning should focus on the idea that Physics is the type of learning that requires higher order thinking skills, such as the ability of diagram representation and critical thinking (Putra &Sudarti, 2015).

Physics mobile learning is a learning medium previously developed by integrating the HomboBatu culture with Android and Physics subjects that is used as a new learning strategy and provides an interesting transformation experience (Saputra, 2018; Yáñez, Okada, & Palau, 2015). Using mobile learning (Android) in the learning process can support higher learning through students' participation in the use of technology, especially using mobile learning in critical thinking processes (Mwest, 2013; Mccann, 2015). Moreover, PML facilitates the students' understanding with regard to the difficulty of physics material in the classroom such as in providing animation, simulation, and learning videos.

Physics mobile learning includes the ability of diagram representation and critical thinking, and it can be used by students to train and develop their abilities in diagram representation and critical thinking (Saputra, 2018). Chennamo, Ross, and Ertmer (2010: 283 & 357) in their study also state that technology and integration of culture understanding support the learning process and are needed by students and that an authentic culture in learning facilitates students in obtaining better understanding in terms of language and culture, especially in improving their ability of diagram representation and critical thinking. Therefore, a research on implementation of PML with HomboBatu theme was conducted to improve the students' ability of diagram representation and critical thinking.

LITERATURE REVIEW

Smartphone Android sebagai M-Learning

Android is a modified Linux-based operating system that is a complete and free open source that has dominated the technology markets (Banks, 2014; Chao, 2012; Huda, 2013; Safaat, 2012). Android can be used as a mobile learning tool (Chao, 2012) which is flexible, wherever and whenever (Ally & Prieto-Blázquez, 2014). Additionally,

Kumar (2013) states that the advantages of using mobile learning in the learning process are: increased mobility; time saving; being environmentally friendly; and interactive.

Mobile learning provides possibilities for students to learn wherever and whenever (Poore, 2013: 144), supports the learning process of Physics, is an efficient learning medium, and facilitates conveyance of the materials or tools (Acedo, 2014; Kumar, 2013; Sarrab, Elgamel & Aldabbas, 2013). Studies have found (Cavus & Uzunboylu, 2009; Cobcroft, Towers, Smith, &Bruns 2015) that mobile technology is able to support the involvement of students in creative, collaborative, critical, and communicative learning activities (Cobcroft et al., 2015).

HomboBatu as learning resource

HomboBatu (StoneJumping), a Culture from Nias Island, is from Bawomatatuo village, Teluk Dalam District. Siregar & Syamsuddin (2015) states "The HomboBatu tradition or stone jumping is a unique local tradition and attracts the attention of the world, and the culture has lived hereditary in the middle of Nias Island people, North Sumatra, Indonesia."

Siregar and Syamsuddin (2015) in their research state that the integration of the HomboBatu tradition into media of character education provides positive characteristics, such as agility, maturity, courage, tenacity, fighting power, and heroism. The culture of HomboBatu (in Fig.1) can be used as a resource of learning on material of Newton's Law and Parabolic Motion.

Figure 1
A. Young is Performing HomboBatu

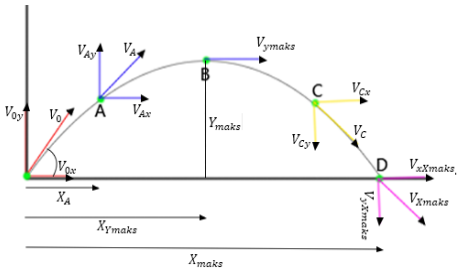

Figure 2
The Example of Parabolic Motion Analysis on HomboBatu

Diagram Representation and Critical Thinking

Frisch (2014) states that representation is the main point in Physics. The ability of representation is often used by experts / scientists to solve problems, but it is not yet being used by students in Physics learning (Gilbert &Treagust, 2009). Representation ability is an important ability of students to solve the problem of Physics (Hubber, Tytler& Haslam, 2010). Representation sometimes has a different meaning in an object (Schnotz, Baadte, Muller, &Rasch, 2010).

Ainsworth (1999) divided representation into three functions: 1) improvement of other representations; 2) to provide an interpretation; 3) to construct a deeper understanding

(Wong, Poo, Hock, & Kang, 2011). Tms and Sirait (2016) provide explanation that various representations are used as an alternative instruction to teach Physics in order that it can facilitate the students in understanding the concepts and problems visually before they understand mathematical equations. Maries and Singh (2013) state that diagram representations are representation providing information on the situation of a system to solve the problems on the system. The free body diagram in the study by Ayesh, Qamhieh, Tit, and Abdelfattah (2010) is a multi-diagram representation that is defined as image representations in problems relating to force.

Critical thinking is a process when a person thinks deeply (Fisher, 2009; Glaser, 1941), analyzes (Fisher, 2001), assess, and evaluates (Abrami, Bernard, Borokhovski, Waddington, Wade &Perrson, 2014) to find athought, an idea, or an assumption (Brookfield, 2012) which has rational reasons to solve a problem (De Cock, 2012; Masek&Yamin, 2011; Stemberg, 1985) so as to obtain a logical conclusion (McGregor, 2007; Gambrill & Gibss, 2009).

METHOD

Research design

This research study is an advanced experimental study with a pretest-posttest control group design (Sugiyono, 2016: 303). The observation of this research covers the control and experimental classes. Experimental class learning uses PML media. During the learning process, students use the Android smartphone as a tool to run the PML application that integrates HomboBatu culture while the control class uses Powerpoint media that does not integrate the HomboBatu culture. The learning process is carried out in the classroom three times in the subject of Newton's Law, both in experimental class and control class using the scientific approach and the model of Learning Discovery.

Participants

This research was conducted at SMANN 6 Yogyakarta with an experimental class sample (X MIPA 7) totaling 22 students and a control class (X MIPA 4) with a subject of 32 students. The sample selection was done randomly (cluster random sampling) from all class X of SMAN 6 Yogyakarta.

Research Instrument

The research instrument used in this study is those pre-posttest questions which are arranged based on indicators (Table 1) in the ability of diagram representation and critical thinking and that have been validated by experts and tested empirically. Empirical tests are analyzed with QUEST software. The questions tested consisted of 17 description questions made up of five questions regarding the ability of diagram representation and 12 questions of critical thinking skills. Question items are in the Infit Mean Square (MNSQ) range with a limit of 0.77 - 1.30 and using INFIT t with the item acceptance criteria is INFIT $t \leq 2$. The results of the analysis can be seen in Fig. 3.

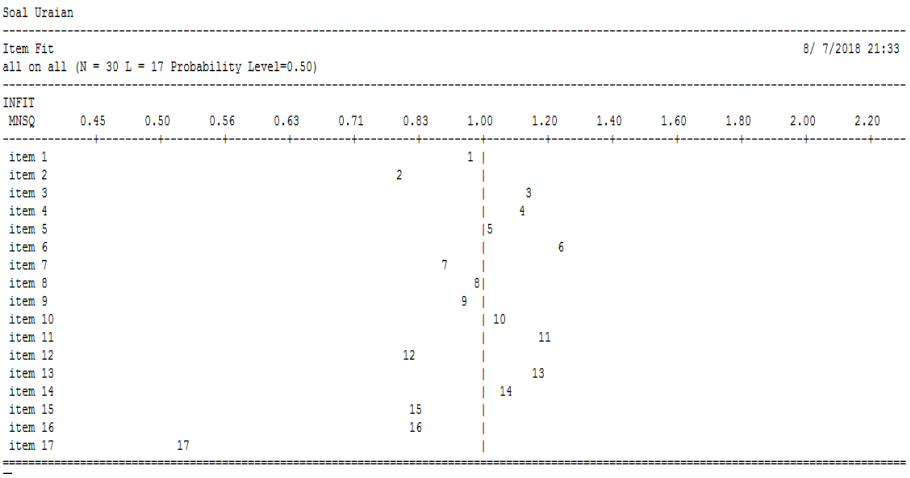

Figure 3
Analytical Results of Emperical Trial

The question consists of 17 questions which are divided into five diagram representation items (items 1-5) and critical thinking questions (items 6-17). The interpretation of the above analysis shows that only item number 17 (critical thinking question) has INFIT MNSQ <0.77, meaning that item number 17 is not suitable or fit with a PCM model or 1-PL model with an acceptable limit of 0.77 - 1, 30, so that only item number 17 cannot be used in field trials (experiments). The results of reliability obtained are 0.713, with a reliable category based on the theory of Gliem and Gliem (2003). The pretest and posttest questions used in the study were only eight essay questions about the application of Newton's Law consisting of three diagram representation questions and five critical thinking questions. The pretest issue is given before the learning begins while the posttest is done at the end of the meeting (final).

The application of Physics mobile learning takes into account the indicator aspects of diagram representation and critical thinking. The use of Physics mobile learning in improving the ability of diagram representation in Newton's Law material and Parabolic Motion is adjusted to the indicators and is shown in Table 1.

Table 1
Matrix of Media

Indicators	Newton Law I	Newton Law II	Newton Law III	Parabolic Motion
Diagram Representation				
Make sketches describing the physics problem	Make sketches a stone, the stone to be jumping start	Students sketch the object in the form a person is running on certain distance according to problem	Make sketches a footstool in the form of a simple diagram (arrows)	Make sketches a parabolic motion on hombobatu culture.
Make an object diagram or external (motions/ forces) on observed object with complete, clear and relevant to physical situation.	Provide a force diagram on stone object	Provide forces diagram, acceleration and mass, and then analyze the relationship among them.	Provide a forces diagram of action and reaction	Make acceleration diagram based on axes x and y.
Provide an clear and correct description/ label on the table	Provide a forces' name of the stone	Provide the correct symbol of acceleration, mass and forces.	Provide name of action and reaction according to opposite direction	Provide correct description on each vector
Using diagram to solve the physics problem	Find out the solution on diagram sketch	Apply Law Newton II with the diagram	Apply Law Newton III	Apply the concept of parabolic motion to HomboBatu
Critical Thinking				
Provide basic explanation	Provide animation of HomboBatu that stand firm. Students are required to explain the stone's inertia	Students explain the basic explanation on relation between mass and forces on a young is running to the stone	Students explain the basic explanation on the reason why a young must rely on stone to make a jump	Students explain the motion of a young when he is jumping
Explain arguments	Students explain their argument on the reason why a young who runs very fast will be hard to stop	Students are asked their arguments why a young who will jump the stone, they must run fastly / not slow	Students explain their argument on landing after a young has finished jumping	Students write their opinion on why parabolic motion occur on hombobatu phenomenon
Conduct a logical thinking	Students analyze the requirement of stone's inertia	Students think the forces and minimum forces that conducted by a young in order he able to jump the stone	Students think the Law Newton III theoretically on HomboBatu culture	Analyze the diagrams of acceleration and velocity on parabolic motion
Conduct an evaluation	Students able to evaluate by calculating the forces diagram on stone pyramid-shaped	Students evaluate on whether the argument and forces on young of hombobatu is relevant to theory of Law Newton II or other theories	Students evaluate and compare the argument to relevant theories	Conduct an evaluation on analysis with GLBB theory
Make decision and determine the further steps	Use Law Newton I to solve the problem on hombobatu phenomenon	Students able to correctly solve the problem when is given problems relating hombobatu	Students are faced physic problem on action and reaction, and they are able to solve the problem	Students are able to solve the GLBB problems

Analysis of Data

Increased Analysis of Representations of Diagrams and Critical Thinking
This increase in pretest and posttest analysis is stated in the Gain standard. The search for Gain standards is as follows with the standard values of gain generated interpreted according to Table 2.

$$Std\ gain < g > = \frac{\bar{X}_{Postest} - \bar{X}_{Pretest}}{X - \bar{X}_{Pretest}}$$

Table 2
Gain Criteria

Value (g)	Category
$g \geq 0,7$	High
$0,7 > g \geq 0,3$	Medium
$g < 0,3$	Low

The MANOVA Statistical Test was carried out using SPSS software. The use of the MANOVA test can be done if it fulfills several assumptions, namely normality, and homogeneity. The MANOVA statistical test in this study was using Hotelling's Trace with a significance level of 5%. The decision criteria taken are H0 rejected if sig <0.05. The research hypothesis in this MANOVA test is as follows:

H_0 : There is no difference in increasing the ability of diagram representation and critical thinking between students who are taught using an Android-assisted learning media with PPT media.

H_1 : There is a difference in increasing the ability of diagram representation and critical thinking between students who are taught using an Android-assisted learning media with PPT media.

Effect Size Analysis

Effect size analysis is used to determine how much influence (contribution) learning uses learning media (HomboBatu) assisted by Android in improving the ability of diagram representation and critical thinking of students. This analysis was carried out in two stages, namely the analysis carried out to find the contribution of learning with Android-assisted Hombo Stone media simultaneously to the dependent variable of the ability of diagram representation and critical thinking. Then the analysis was done separately using the results of the pretest and posttest in each class.

Effect size is obtained by calculating Cohen's f value from the transformation of the eta square value in the Test Table between the subject effects, or alternatively Cohen's f value can be calculated using Cohen's equation in the equation below and Cohen's category can be stated in Table 3.

$$f = \sqrt{\frac{\eta^2}{1 - \eta^2}}$$

Table3
Effect Size Criteria

Effect size	Category
0,2	Small
0,5	Medium
0,8	Large

FINDINGS

In the learning experiment class using RPP with a scientific approach and the Discovery learning model that integrates the HomboBatu culture and Android as a learning medium while in the control class using learning tools commonly used by teachers and not integrating the HomboBatu tradition.Physics mobile learning (PML) is a medium of learning and can be used as a new learning strategy (Cavus&Uzunboylu, 2009), transformative experience in creating a sense of love to culture, new way of learning Physics, and utilizing technology as a means of delivering material.

Mobile learning physics is designed attractively with Adobe animate and Coreldraw X7, which can be seen in Fig. 4. The media is also given an interactive simulation display shown in Fig. 5 and Fig. 6 so that students can explore the force diagram representation and motion diagrams in HomboBatu. In addition, critical questions and interactive explanations are shown in Fig. 7.

Homepage of Media

Interactive Simulation

Figure 6

Diagram Representation on Parabolic Motion

Figure 7

Interactive Questions on the Media

Result of Improvement of Diagram Representation Ability

Diagram representation is the ability of students to solve physical problems (Tuminaro& Edward, 2007; Taufiketal., 2010). The results of this study showed that students analyze and present a problem into a sketch and free body diagram, which way is more effective and facilitates finding solutions for the students (Fredlund et al., 2014). Results of students' ability in diagram representation in control and experimental classis are presented in Fig.8 and Table 4.

Table4
Representation Diagram Ability Test Results

Class	N	Average		Average Gain Value	Category
		Pretest	Posttest		
Control	32	30,89	58,08	0,39	Medium
Experiment	22	29,61	84,29	0,78	Large

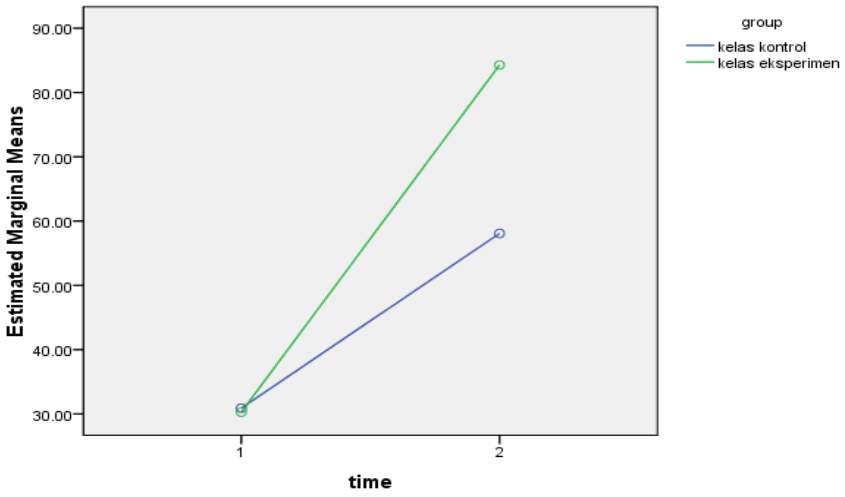

Figure 8
Graph on Improvement Results of Average Score of Students' Ability of Diagram Representation

The students pretest results in control class (number 1) and experiment class (number 2) are in the same starting point (see Fig.8) means that the students' initial ability in the control and experimental class has the same level of ability of diagram representation.

Figure 8 and Table 4 show that both control class and experimental class have an improvement on the ability of diagram representation. But the improvement on ability of diagram representation in experimental class is higher than in control class. This provides the information that learning media (HomboBatu) in learning is more effective in improving the students' ability of diagram representation than is PowerPoint media. This is due to learning media (HomboBatu) Android-assisted better being able to

visualize the forces diagram of Newton's Law than Powerpoint media, and students who use diagram representation can more optimally solve the Physics problems (Tms&Sirait, 2016). In addition, the advantage of learning media (HomboBatu) is in providing students with a more concrete learning experience where the students use the media interactively, independently, and collaboratively.

Result of Improvement of Critical Thinking Ability

Critical thinking is the mental process when we think deeply to find an idea, thought, or assumption with having rational reasons so as to obtain a logical conclusion through several stages such as asking, analyzing, synthesizing, logical thinking, and evaluating (Fisher, 2001; Glesser, 1941; Sternberg, 1985). The learning process with tradition-based Android-assisted media aims to improve students' critical thinking ability through the use of this Android-assisted media. Several treatments are loaded to the media such as basic questions on Newton's Law, animation to allow students analyzing the phenomena and so on. The results of the improvement of critical thinking ability are presented in Fig. 9.

Table 5
Result of Improvement of Critical Thinking Ability

Class	N	Average		Average Gain Value	Category
		Pretest	Posttest		
Control	32	30,20	66,86	0,53	Medium
Experiment	22	30,96	67,91	0,54	Medium

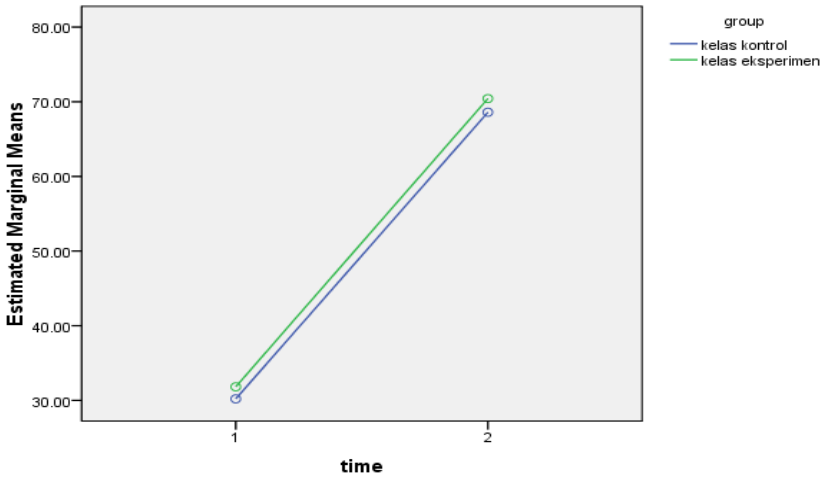

Figure 9
Graph on improvement Results of Critical Thinking Ability

Figure 9 and Table 5 describe the initial critical thinking ability of students seen from the pretest score with the score does not reached the minimum passed criteria scores of schools, both control class and experimental class show the same score of initial ability,

and there is no significant difference between initial ability of control class and experimental class (Homogeneous). In posttest score, both control class and experimental class have an increase in critical thinking ability as compared with pretest score. The experimental class has higher increase than control class, but differences are not significant. Based on Fig. 6, there is no significant difference in the results of pretest-posttest in control class and experimental class.

The improvement of critical thinking ability belongs to the medium category, because the posttest scores after treatment of the learning with Android learning media have not reached the minimum school criteria. The reason is because the time in learning is not maximized, but the increase of average score of experimental class is higher than that of control class although the differences are not significant. Learning with Android-assisted media with HomboBatuculture theme can therefore improve the students' critical thinking ability. These results are relevant to those of the previous studies (Cavus & Uzunboylu, 2009; Cobcroft, Towers, Smith, & Bruns, 2015) which found that M-learning technology is able to support the students' involvement in creative, collaborative, critical, and communicative learning activities (Cobcroft et al., 2015).

The analysis in this study used the MANOVA test to determine the difference in control classes with conventional learning and the experimental class with learning using an assisted Android Smartphone learning media with regard to the theme of the tradition of HomboBatu. Test the assumptions made are normality and homogeneity test with the results as follows.

Table 6
Normality Test Results

	Class	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Repretation Diagram	Control	.126	32	.200*
	Experiment	.117	22	.200*
Critical Thinking	Control	.102	32	.200*
	Experiment	.113	22	.200*

Table 7
Homogeneity Test Results

	F	df1	df2	Sig.
Repretation Diagram	.891	1	52	.349
Critical Thinking	1.987	1	52	.165

The result of the normality and homogeneity test shows that the data are normally distributed and homogeneous. The MANOVA test was conducted to see whether there were differences in the control class with conventional learning and the experimental class with learning using Android-assisted learning media with the traditional HomboBatu theme. MANOVA test results with SPSS can be seen in the following table.

Table 8
Result of Hotelling's Trace

Effect	sig.	Criteria	Decision
Hotelling's Trace	.000	sig.<0,05	$H_0$is rejected

In the table above, the MANOVA test used is the Hotelling Trace test with an f value of 21.863 with a sig value of 0.000 smaller than the significance level of 0.05. Thus, the hypothesis which states that there is a difference between classes taught with Android assisted learning media with the theme HomboBatu and classes taught conventionally (using PPT media), is accepted (Ho rejected). It was concluded that there were significant differences in the ability of diagram representation and critical thinking simultaneous to the control class and the experimental class.

Table 9
Tests of Between-Subjects Effects

Source	Dependent Variable	df	Mean Square	F	Sig.
Kelas	Representation diagram	1	9849.411	43.803	.000
	Critical thinking	1	1.154	.003	.956

On the Test of Table of Effects subjects, we can see whether there is an influence of the control class and the experimental class on each of the critical thinking ability variables and diagrammatic representations, separately. If the sig value is smaller than 0.05 then there is a significant difference in each variable. From the results above, it can be interpreted that:

a) Significant differences exist in the control class and experimental class in the ability of diagram representation, with a value of sig 0,000.
b) There is no significant difference between the control and experimental classes on critical thinking skills with a sig value of 0.965 greater than the significance level (0.05). This can be seen in the average value of the control class gain of 0.53 while the experimental class is 0.54. Only 0.01 is the difference between the two. So, if analyzed at a significance level of 5%, there is no significant difference between the class with conventional learning (PPT) and the experimental class with Android-assisted media themed HomboBatu. Even if you see it, there are still differences in both of them, even if only a little. This is because learning media is not maximal to train students'' critical thinking.

Analysis of Effect Size Effect

After it is known that learning with Android-assisted Hombo Stone media influences the ability of diagram representation and critical thinking ability, an analysis is conducted to find out how much influence the learning has. The next analysis is done separately based on the dependent variables, namely diagrammatic ability and critical thinking involving the pretest and posttest of each dependent variable, therefore, the multivariate significance seen is that Hotelling's traces can be seen in Table 10.

Table 10
Analysis of the effect of learning on the ability of diagram representation

Group		F	Sig.	Partial Eta Squared	Category
Control	Hotelling's trace	1.102E2[a]	.000	.679	Medium
Experiment	Hotelling's trace	2.991E2[a]	.000	.852	Large

Based on Table 10 it is known that the application of Android-assisted Stone Hombo learning media has an effect on increasing the ability of diagram representation with significance (p<0.05) and with a contribution of an increase of 0.852 in the "high" category and a control class treated with PPT learning media, the effect on the improvement of the ability of Science Literacy in the affective aspect was with significance (p<0.05) of 0.679 with the "medium" category.

Table11
Analysis of the effect of learning on critical thinking abilities

Group		F	Sig.	Partial Eta Squared	Category
Experiment	Hotelling's trace	2.056E2[a]	.000	.798	Medium
Control	Hotelling's trace	1.430E2[a]	.000	.733	Medium

Based on Table 11 it is known information that the application of Android-assisted Hombo Stone learning media has an influence on increasing critical thinking skills with significance (p<0.05) with an increase in contribution of 0.798 with the category of "medium" and the control class treated with PPT learning media giving the effect of increasing critical thinking skills with significance (p<0.05) of 0.733 with the "medium" category. Based on this data, it can be concluded that there is no significant difference in the effects of learning with PML learning media assisted by Android smartphones with PPT assisted learning in improving critical thinking skills of students. However, the effect given by the PML learning media is greater, although the magnitude of the influence of the HomboBatu media with PPT media is not too far away (0.798 with 0.733). This is because HomboBatu's learning media has not been maximal to train students' critical thinking and must be revised to be more effective in improving critical thinking skills.

CONCLUSION

In this study, the effect of Hybrid-PjBL on learning outcomes, creative thinking skills, and increased learning motivation was studied at higher education level. The results of this study indicate that there were significant differences between students who were taught using PjBL learning and the counterparts by conventional learning, both on the parameters of learning outcomes and creative thinking skills. Furthermore, although it did not have any significant difference with the control class, Hybrid-PjBL has had the potential to increase student's learning motivation. The results of this study suggest that Hybrid-PjBL is an alternative form of learning relevant to the demands of the 21st Century. Assessment of the implementation of Hybrid-PjBL on other parameters needs to be developed in future studies to uncover the positive impact of the model more

thoroughly. The addition of study duration is also recommended so that the long-term impact of Hybrid-PjBL can be analyzed.

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