Training Students' Thinking Skills using Problem-based Learning Integrated with Virtual Mobile Learning

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Abstract: Learning based on science, technology, engineering and mathematic (STEM) in the 2013 curriculum can be implemented through the application of a combination of problem-based learning and virtual mobile learning. This research aimed to train thinking skills of students in SMA Negeri 01 Manokwari through the application of problem-based learning combined with virtual mobile learning. One-shot case study was operative in this research. A total of 126 students in the XI_{MIA} class of SMA Negeri 01 Manokwari were involved as research subjects. Data collection techniques include learning achievement tests and thinking skill rubrics based on SOLO Taxonomy. Data analysis were in the form of percentage of achieving thinking skill and inferential analysis used Kruskal-Wallis. The results indicate that the students' level of thinking skills has reached relational level or level 4, and the highest percentage of thinking skill levels achieved by students was at level 3 or multistructural level. The significant values of the five treatment groups were $0.120 > 0.05$, indicating that there was no differences in the achievement of thinking skills among five treatment groups. The study has concluded that problem-based learning combined with virtual mobile learning can be deployed to foster students' thinking skills.

1 INTRODUCTION

Problem-based learning is a recommended learning strategy in the 21st century class. The application of effective learning models in the classroom is expected to improve students' learning outcomes and empower their potential. Teaching is not based on the teacher's preference, but needs to be determined based on the students' competence as well (Damopolii, Nunaki, & Supriyadi, 2018). Teachers in problem-based learning (PBL) classes facilitate the learning process by monitoring their students' progress and asking questions to encourage them to excel in problem solving process (Major & Palmer, 2001). In fact, students consider problem-based learning effective learning (Hallinger & Lu, 2011).

Several previous studies show that there is an influence of learning models based on students' learning achievement problems on students' achievement (Demirel & Dağyar, 2016; Günter, Akkuzu, & Alpat, 2017; Taşoğlu & Bakaç, 2014). The implementation of PBL empowers students' critical thinking skills (EL-Shaer & Gaber, 2014; Gholami et al., 2016; Zabit, 2010), creative thinking skills (Birgili, 2015; Ersoy & Başer, 2014; Murni & Anggraini, 2016), problem solving skills (Darma, 2018; Nasution, Yerizon, & Gusmiyanti, 2018; Sihaloho, Sahyar, & Ginting, 2017), and levels of structuring concepts (Inel & Balim, 2010). Research students in the Department of Biology Education in Universitas Papua have found that there is no significant effect of PBL implementation on students' learning achievement (Sogen, Damopolii, & Kilmaskossu, 2018; Zannah, Iwan, & Damopolii 2018), and fair influence is evident on student attitude in Science (Batdı, 2014). Some studies acknowledge the effect of PBL on achieving student learning objectives, but on the other hand some studies claim that there is no significant effect. The author also found that there was no measurement of thinking skills based on SOLO taxonomy of students in learning to implement PBL integrated with technology. As such, it is necessary to deploy a technology to help students achieve SOLO taxonomy, where the technology must comply with the demands of STEM-based curriculum in Indonesia and student development.

Based on the results of direct observation and interviews, the researcher has found that SMA Negeri 01 Manokwari is a school with fairly complete ICT

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facility and competent human resources. This can be seen from the ability of teachers and students who are skilled enough to operate ICT facilities such as Infocus, computers, laptops, and smartphones. Of the 331 students in class XIMIA of SMA Negeri 01 Manokwari, there are 302 students or 91% of students who use Android-powered smartphones. The data shows that Android-based smartphones are a type of mobile device that is very popular and most sought after by the students of class XIMIA SMA Negeri 1 Manokwari. These conditions should strongly support more innovative learning by utilizing the available ICT facilities. However, the availability of fine ICT facilities and competent human resources in the school has yet to accrue optimal biology learning.

The utilization of ICT in learning is known as e-learning. The newest branch or part of e-learning is mobile-based learning or mobile learning (Georgieva, Smrikarov, & Georgiev, 2005) Mobile learning is flexible because it can be changed or updated at any time, particularly if there are changes in material, especially in the field of science that has improved with respect to its theory. In principle, mobile learning aims to facilitate learners anywhere and anytime according to their place (Wilson & Bolliger, 2013). Mobile learning is virtually accessible from anywhere, by providing access to various learning materials.

Mobile devices that can be used for the development of learning media are smartphones (smartphones) (Squire, 2009). The use of this smartphone is put in experiment by Dewanti to connect smartphone usage with students' learning achievements, the results of which show that there is a significant correlation between smartphone usage and students' learning achievement, where the use of smartphones positively affects students' learning achievement, with higher smartphone usage resulting in higher students' learning achievement (Dewanti, Widada, & Triyono, 2016). Good achievement results from their good thinking skills. One of the thinking skills is SOLO taxonomy level of thinking skill. Today, SOLO taxonomy has been used to measure students' thinking skills (Seiter, 2015). The level of SOLO taxonomy is divided into five stages, namely prastructural, unistructural, multistructural, relational and extended abstract (Wells, 2015), each of which is used in various subjects (Biggs & Collis, 1982), including biology (Minogue & Jones, 2009).

A study by Uzunboylu, Cavus & Ercag suggests the use of mobile learning in large-scale study (Uzunboylu, Cavus, & Ercag, 2009), In addition, it is suggested to delve into the more implementation of PBL in the future (EL-Shaer & Gaber, 2014), and PBL improvements to previous research. As such, study focusing on use of mobile-assisted virtual PBL is expected to accrue good effect in training thinking skills based on SOLO taxonomy.

2 METHOD

This research was an experimental study using a one-shot case study. The subjects in the study were students of XIMIA class at SMA Negeri 01 Manokwari. Five classes were involved as treatment classes, namely XIMIA3 with 29 students (group 1), XIMIA5 with 29 students (group 2), XIMIA6 with 20 students (group 3), XIMIA7 with 24 students (group 4), and XIMIA8 with 24 students (group 5). As such, a total of 126 students were involved in the study. The research was carried out in the even semester of 2017/2018 school year, starting from March 27 2018 to May 18, 2018.

Learning instruments used in the study included lesson plan, student worksheets, achievement tests, and Android-based virtual mobile learning. Learning instrument was adapted to the 2013 curriculum applied by SMA Negeri 01 Manokwari. Lesson plan was constructed and arranged in the form of HOTS lesson plan (High-Order Thinking Skills Lesson Plan). Android-based mobile learning media and student worksheets were implemented in the form of the syntax of Problem Based Learning (PBL) activities. Tests of learning outcomes included five items. This learning instruments were used to assist the learning process in order to achieve the learning objectives. To measure thinking skills, a five-level rubric was used, which comprised of prastructural, unistructural, mutistructural, relational and extended abstract.

The production phase of mobile learning commenced with preparing instrument and materials used in the process of making Android-based mobile learning media. The equipment used by researchers were PC hardware, ACER ASPIRE E5-471-30Q8, appypie website and Android smartphone OPPO E37. Materials needed in the process of making android-based mobile learning media was a good WIFI signal so that the learning process ran smoothly, Youtube video URL related to the material of the human reproductive system, images of human reproductive system material, various material summaries in the form of Microsoft Word , and multiple choice quiz questions in Microsoft Word format. After preparing the necessary instrument and materials, the researcher made a storyboard or general description that showed the storyline and the process of using the instructional media. Storyboard was made in the form of smartphone display slides. Each slide had different functions and views with different button as well as settings, background and animation effects. Storyboards that had been created were then processed online at www.appypie.com.

Validity of research data was obtained from the validation instrument sheet. This validation instrument sheet applied 1-5 Likert scale with alternative answers comprising of 1) irrelevant, 2) less relevant, 3) quite relevant, 4) relevant and 5) very relevant. Validation sheets were filled in by three validators, including media expert, material expert and biology learning practitioner. Validation results showed that lesson plan, student worksheet, achievement test, and virtual mobile learning were valid and applicable for learning process.

Data analysis, in the form of achievement percentage of each thinking skill level and inferential analysis using the Kruskal-Wallis test was made operative to find out any significant differences among classes and its effect on tinking skill.

3 RESULT AND DISCUSSION

Based on the results of the study applying problem-based learning assisted by virtual mobile learning in five treatment groups, crucial data have been garnered in the form of achievement percentage of each thinking skill level and the analysis of differences in thinking skills using Kruskal-Wallis. The following is the data from the analysis:

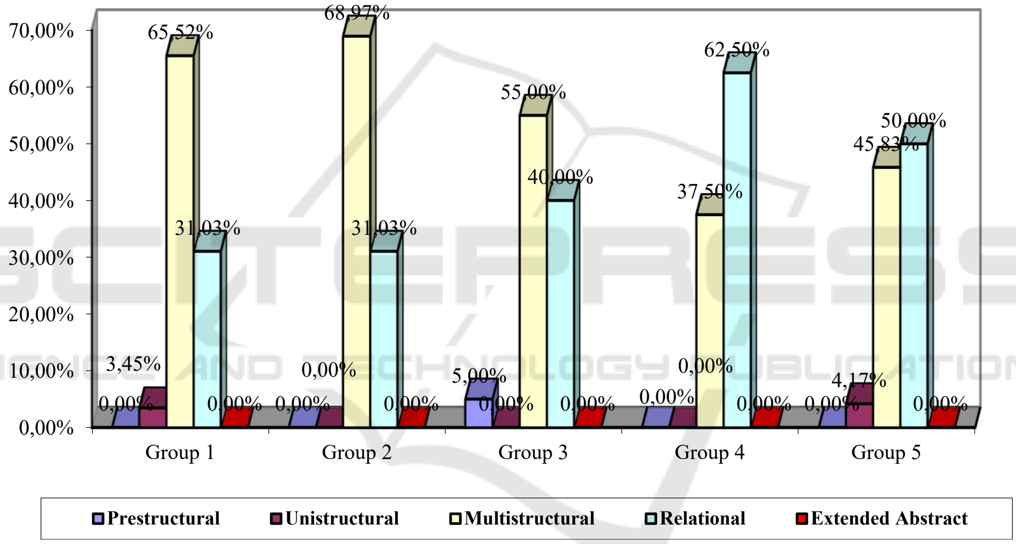

Figure 1: Students' achievement with to thinking skills based on SOLO taxonomy

Figure 2 demonstrates that each group has different thinking skill achievements. In all treatment groups, achieving the thinking skill level is at the relational level. In groups 1, 2 and 3, the highest level of thinking skill from students reaches the multistuctural level, while groups 4 and 5 reaching the highest achievement at the relational level. The prestige level in group 3 reaches 5%, while the other groups have yet to reach this level. Unistructural levels in group 1 reach 3.45% and group 4 reach 4.17%, while the other groups have not reached the same level. In all groups, no students have reached the extended abstract level.

When a total of 126 students are taken into account; 55.56% of students reach the multistructural level; 42.06% of students reach relational level; 1.59% of students reach an unistructural level; 0.79% of students reach prestructural level; and 0% of students reach extended abstract level. These data conclude that PBL assisted virtual mobile learning can foster students' thinking skills to reach relational levels. The highest percentage of achieving thinking skills is at the multistructural level.

Table 1: Analysis results of Kruskal-Wallis on thinking skills based on SOLO taxonomy

	Group	N	Mean Rank	Chi-Square	df	Asymop. Sig.
Thinking Skills	1	29	56.34	7.238	4	0.120
	2	29	57.59			
	3	20	61.23			
	4	24	76.94			
	5	24	67.75			
Total		**126**				

Table 1 indicates that there is no difference in the achievement of SOLO taxonomy level of thinking skills in the five treatment groups. This shows that the achievement of SOLO taxonomy level of thinking skill in each group taught using the problem based learning model assisted by mobile learning is similar.

Good thinking habits raise questions to direct students' learning, by taking into account various and varied kinds of problems, finding out how to solve problems through various types of inquiry, and thinking independently (Chin & Chia, 2006). Students have positive opinions in learning using PBL models. This is indicated by their interest in the problems given by the teacher. Because the problems given are related to the phenomena of everyday life, students can be empowered to develop lifelong learning (Günter et al., 2017; Tseng, Chiang, & Hsu, 2008). Mobile learning is the opposite of learning that occurs in conventional classes, where it is not just a machine, but an inseparable instrument (Jinlong, Zhaolei, & Yawei, 2012; Woodill, 2011).

The combination of problem-based learning with virtual mobile learning makes learning process better. The results are found to improve previous research that indicate influence at medium extent (Batdı, 2014), and some other studies which reveal no effect of problem-based learning in student learning achievement (Sogen et al., 2018; Zannah et al., 2018). With the use of PBL combined with virtual mobile, students become active and thus can observe objects of biological learning through pictures and videos presented in mobile learning. This can also overcome the limitations in learning due to insufficient laboratory facilities in schools, support efficient use of budget, and provide practicality and flexibility for students. Students can study at home because mobile-learning that has been designed is stored on their smartphone. In mobile learning, today's students are always connected to the internet. According to Shen et al., 95% of students are interested in taking distance learning through internet (Shen, Wang, Gao, Novak, & Tang, 2009). In mobile learning, there is also a consultation section if students want to ask questions about the concept related to a material.

Learning with the use of PBL requires students to solve problems collaboratively in groups. Mobile learning is there to help students find the information they need, because mobile learning is connected to the internet. In real-world situations, students individually use mobile learning to support their learning and increase their understanding, especially because it is connected to a computer system using wifi (Ahmed & Parsons, 2013; Chu, Hwang, Tsai, & Tseng, 2010). Wifi has a great effect on learning (Roschelle, 2003), which supports learning activities (Vogel, Spikol, Kurti, & Milrad, 2010).

In the learning process under investigation, students find it easier to obtain information, because they do not need to carry heavy textbooks provided by school libraries. Rather, they can simply use smartphones for more positive purposes. As a result, the learning process becomes more enjoyable and suits the demands of today's generation, and at the same time reduces the adverse effect of smartphones being laden with negative content or game related apps. Survey conducted by Shen et al reveals that 9.5% of mobile phones are used for learning (Shen et al., 2009). With the innovation allowing instructional purpose of mobile phone, smartphone becomes even more useful.

4 CONCLUSIONS

Based on the research results, it can be concluded that problem-based learning assisted by virtual mobile learning can foster students' thinking skills based on SOLO taxonomy. The students' achievement with regard to thinking skill level reaches the relational level (level 4), and the highest percentage of achieving SOLO taxonomy level of thinking skills is at the multistructural level (level 3). Future research can apply particular learning strategy to excel student' thinking skills to reach the extended abstract level (level 5). It can delve into the relationship between achieving particular SOLO level of thinking skill and students' learning achievement.

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