The effect of mobile learning and motivation for students’ High Order Thinking Skills (HOTS) in electrolyte and nonelectrolyte solutions learning

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ABSTRACT: This study aimed to determine the effects of mobile learning on Higher Order Thinking Skills (HOTS) of students associated with students’ learning motivation. The research was conducted on students in the 10th grade at a public high school in Bogor, West Java in the 2017/2018 academic year. The research method used was quasi-experimental with a two-way ANOVA design (treatment by level 2 × 2). The samples included 36 students who were selected using the simple random sampling technique. In the experimental group, the learning process was conducted using mobile learning, which was validated by experts and tested by teachers and students, while in the control group the learning process was conducted using PowerPoint media. This research concluded that mobile learning had positive effects on the higher order thinking skills of students when it was applied to students with high learning motivation; for students with low learning motivation, mobile learning did not have any effects of higher order thinking skills; there was an interaction between mobile learning and motivation on higher order thinking skills of students.

1 INTRODUCTION

Nowadays, students require 21st century skills in order to have higher order thinking skills so that they can be competitive in facing global problems. Indonesia was ranked 69 out of 76 countries in PISA 2015 (OECD 2015). The results of TIMMS IPA for the 8th grade in 2011 showed that more than 95% of Indonesian students were only able to think at a middle level or master science at the level of application thinking (TIMSS 2011). These results showed that Indonesian students could not do critical thinking in the problem-solving of high levels of thinking. The low level of students’ thinking skills can be seen from the level of problems in exam questions that were still limited to lower order thinking skills (LOTS). The government made an effort to introduce 21st-century skills by developing the new curricula of 2013. This curriculum incorporated 21st century learning skills that were integrated with the content and learning process so that students had the competitive ability of higher-order thinking in resolving any problems that were complex. However, in the context of the study, it was found that teaching methods were mostly conducted by a teacher-centered method, which lead to students’ passive learning. The school teachers become the main source for students to acquire knowledge.

HOTS will be achieved if students are given the stimulus in the learning process that can improve their thinking processes. According to Bloom’s taxonomy, high order thinking skills (HOTS) is called critical thinking, creative thinking, problem-solving, making decisions and metacognitive in nature (Yen & Halili, 2015). Heong et al., (2011) explained that the ability of high order thinking is the widespread usage of the mind to find new challenges. This high-level thinking capability requires a person to apply new information or prior knowledge and manipulate information to reach possible answers in new situations. Bookhart (2010) states that providing a stimulus can make students able to think in the form of introductory texts,
visuals, scenarios, or various kinds of problems so that proactive learning occurs. Ealy (2015) concluded that HOTS could be stimulated by using visual media. Simon (2015) developed and fostered students’ thinking skills and HOTS of students by using simulation software and virtual experiments in a laboratory environment. According to Li et al., (2016), teaching with e-schoolbags applications such as virtual simulation, cognitive tools, instant feedback, and portfolio learning, can foster HOTS of students, especially analytical and evaluation skills.

Learning media will provide a stimulus to improve students’ thinking skills. The learning motivation possessed by students can influence students’ thinking processes in learning towards a more complex direction. Torkoguz (2012), explained that the process of learning chemistry would be better if using media or technology that could visualize the chemicals used. Furthermore, based on previous research learning, using mobile learning has a positive effect on chemistry learning outcomes (Cahyana et al., 2017). The main purpose of science education is to help students improve HOTS, thus helping them to face challenges in everyday life by enhancing cognitive skills such as critical thinking, reflective thinking, and individual process skills (Zachariades et al., 2013). Mobile learning media will provide a stimulus in the form of audio and visuals, games, and quizzes that can be used by students to learn anywhere and anytime (Traxler, 2009). Then Miller’s research (2017), concluded that students were more confident in learning when they use mobile devices, showing a greater change in interest and learning motivation than learning through textbooks. According to McQuiggen et al., (2015), mobile learning has many advantages: (1) it enables students to learn anywhere without being limited by place and time; (2) it is more economical, so it can reach students and schools that lack facilities; (3) the features of mobile learning media are able to increase HOTS of students; (4) provides alternative learning environments for students; (5) cultivates students’ knowledge and makes it easier to track the difficulties that each student faced; and (6) fosters students’ learning motivation. According to Ciampa (2013), motivation can be enhanced through the challenge, curiosity, control, recognition, competition, and cooperation. This study aimed to determine the effect of mobile learning on higher order thinking skills (HOTS) of students associated with students’ learning motivation.

2 METHODOLOGY

This research was conducted at a state high school in Bogor, West Java in the even semester of the 2017/2018 academic year. The method used in this research was a quasi-experimental method with a two-way ANOVA research design (treatment by level 2 × 2). The experimental research design by factorial level can be seen in Table 1.

Samples in this research consisted of 36 students in 10th grade selected by the simple random sampling technique. Mobile learning with the topic of electrolyte and nonelectrolyte solutions used in the experimental group has been validated by experts and tested by teachers and students. Students in the control group used PowerPoint media. Data was collected using validated tests and questionnaires. Tests for measuring students’ HOTS consisted of 16 questions, and a questionnaire to measure learning motivation that consisted of 38 questions. The calculation of an instrument’s validity used the Karl Pearson’s product moment correlation and the calculation of reliability used the Cronbach’s alpha formula.

Table 1. Research design two-way ANOVA (treatment by level 2 × 2).

<table>
<thead>
<tr>
<th>Motivation (B)</th>
<th>Learning media (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mobile learning (A₁)</td>
</tr>
<tr>
<td>High Learning Motivation (B₁)</td>
<td>A₁B₁</td>
</tr>
<tr>
<td>Low Learning Motivation (B₂)</td>
<td>A₂B₁</td>
</tr>
</tbody>
</table>
Before analyzing the data, the students’ score was tested for normality using the Liliefors test and homogeneity using the Fisher and Bartlett test. There were four hypotheses in this research. The first (main effect) and second hypotheses (interaction effect) were tested by two-way analysis of variance technique (ANOVA), then the third and fourth hypotheses (simple effects) were tested using the Tukey test.

3 RESULTS AND DISCUSSION

This research determined the effect of mobile learning on HOTS of students associated with learning motivation.

3.1 The effect of mobile learning on HOTS of students

Based on the results of hypotheses testing (Table 2), the Fcount was 8.78, while the Ftable value at the significance level (α) = 0.05 is 4.15. Because the value of Fcount > Ftable, then H0 is rejected, so it can be concluded that HOTS of students who are using mobile learning is higher than students who use PowerPoint media. It is because mobile learning has more advantages, such as the ability to access information and subject materials anywhere and anytime from a device that students carried everywhere (Traxler, 2009). Mobile devices are considered as a leading factor in the learning process (Huang et al., 2010; Gedik et al., 2012; Navaridas et al., 2013). Mobile learning can combine learning with lots of time and diverse learning, it can also foster students' learning motivation (McQuiggan et al., 2015). Furthermore, Miller (2017) explains that students are more confident when learning to use mobile devices; their interest and motivation to learn is greater than learning through textbooks. Cavusa & Uzunboylub (2009), explained that learning with mobiles has a positive impact on students' attitudes and creativity, and increases their critical thinking skills, unlike the students who are taught using PowerPoint media. Generally, PowerPoint media is in the form of impressions combined with the lecture method. PowerPoint media is more teacher-centered; it makes students less active in the classroom, learning becomes monotonous because students only receive the information from teachers theoretically, so their thinking is only memorizing, which is a low level of thinking. This condition can decrease students' learning motivation.

So the use of mobile learning has a positive influence in improving students' high-level thinking skills (HOTS). Students can access material or information wherever and whenever, and are not bound by space and time. Learning material contained in mobile learning is equipped with games, animations, quiz questions and learning videos so that it can increase learning motivation and provide stimulus in learning, so students can be trained to think at a higher level.

3.2 Interaction between Mobile Learning (A) and Motivation (B) toward HOTS of students

Based on the hypothesis testing results (Table 2), the obtained value of Fcount is equal to 62.15. Whereas, the Ftable value at the significance level (α) = 0.05 is 4.15. As the Fcount >

<table>
<thead>
<tr>
<th>Variance</th>
<th>Db</th>
<th>JK</th>
<th>RJK</th>
<th>F count</th>
<th>F table</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between A₁ &amp; A₂</td>
<td>1</td>
<td>289,00</td>
<td>289,00</td>
<td>8.78</td>
<td>4.15</td>
<td>Ho Rejected</td>
</tr>
<tr>
<td>Interaction A X B</td>
<td>1</td>
<td>2045,05</td>
<td>2045,049</td>
<td>62.15</td>
<td>4.15</td>
<td>Ho Rejected</td>
</tr>
<tr>
<td>In group</td>
<td>32</td>
<td>1052.94</td>
<td>32.90</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Total (T)</td>
<td>36</td>
<td>222608.44</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
</tbody>
</table>
Ftable, then H0 is rejected, so it can be concluded that there is an interaction between learning media and learning motivation toward the HOTS of students. The interaction shows that each learning media has a different influence on HOTS of students when used by groups of students who have different learning motivation. The results showed that mobile learning is more effective when it is used by students who have high learning motivation. The interaction between learning media and learning motivation can be seen in Figure 1.

Based on Ealy’s research (2015), high order thinking skills can be stimulated by using visual media. Furthermore, Simon’s research (2015) explained it could develop and foster students’ critical thinking skills by using simulation software and virtual experiments in a laboratory environment. This is in line with the study of Li et al. (2016), which explained that teaching with e-schoolbags applications such as virtual simulation, feedback, and portfolio learning can foster high order thinking skills, especially analytical and evaluation skills.

So the use of learning media will provide a stimulus to improve students’ thinking skills. The learning motivation possessed by students influences students’ thinking processes in learning, so that with learning media and higher learning motivation, students will influence thinking skills toward more complex ones. Based on the description above, it can be concluded that there is an interaction between learning media and learning motivation toward HOTS of students.

3.3 **The HOTS of students’ differences between A,B₁ and A,B₁**

Based on the results of hypothesis testing (Table 3), the Qcount was 10.85. The value of Qtable at the level of significance (α) = 0.05 is 4.41. Therefore, the value of Qcount > Qtable, then H0 is rejected, so it can be concluded that HOTS of students who were taught by using mobile learning is higher than students taught by using PowerPoint media with students who have high learning motivation. The results also show that mobile learning is more effective than PowerPoint media if used with students who have high learning motivation.

The principles of Keller’s motivation (2008) consists of 4 (four) categories, namely attention, relevance, confidence, and satisfaction. Students who have a higher motivation to learn

![Figure 1. Graph of the interaction between learning media and learning motivation toward HOTS of students.](image)

**Table 3. Hypothesis testing results using Tukey test.**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Q count</th>
<th>Q table</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>A₁B₁</td>
<td>9</td>
<td>10.85</td>
<td>4.41</td>
<td>Ho Rejected</td>
</tr>
<tr>
<td>A₂B₁</td>
<td>9</td>
<td>4.92</td>
<td>4.41</td>
<td>Ho Rejected</td>
</tr>
<tr>
<td>A₁B₂</td>
<td>9</td>
<td>4.92</td>
<td>4.41</td>
<td>Ho Rejected</td>
</tr>
<tr>
<td>A₂B₂</td>
<td>9</td>
<td>4.92</td>
<td>4.41</td>
<td>Ho Rejected</td>
</tr>
</tbody>
</table>
have a higher interest or curiosity when studying a thing or material, and assume that the subject material will benefit their lives.

3.4 **The HOTS of students differences between $A_1B_1$ and $A_2B_2$**

Based on the results of hypothesis testing (Table 3), the Qcount was 4.92. The value of $Q_{table}$ at the level of significance ($\alpha$) = 0.05 is 4.41. For the value of $Q_{count} > Q_{table}$, H0 is rejected, so it can be concluded that HOTS of students who were taught by using mobile learning is lower than students taught by using PowerPoint media with students who have low learning motivation.

Students who have low learning motivation tend to follow the learning process as it is and accept the structure of the material that has been determined by the teacher so that learning planning is systematically arranged. The learning process with PowerPoint media is more beneficial for students who have low learning motivation, in other words mobile learning is not suitable for students who have low learning motivation because it requires students to have high learning independence so students will be motivated in learning. This is consistent with the research of Cahyana et al., (2017) in that mobile learning has a positive effect on the learning outcomes of chemistry in groups of students who have high independence.

3.5 **The HOTS of students differences between $A_1B_2$ and $A_2B_2$**

Based on the results of hypothesis testing (Table 3), the Qcount was 4.92. The value of $Q_{table}$ at the level of significance ($\alpha$) = 0.05 is 4.41. For the value of $Q_{count} > Q_{table}$, H0 is rejected, so it can be concluded that HOTS of students who were taught by using mobile learning is lower than students taught by using PowerPoint media with students who have low learning motivation.

Students who have low learning motivation tend to follow the learning process as it is and accept the structure of the material that has been determined by the teacher so that learning planning is systematically arranged. The learning process with PowerPoint media is more beneficial for students who have low learning motivation, in other words mobile learning is not suitable for students who have low learning motivation because it requires students to have high learning independence so students will be motivated in learning. This is consistent with the research of Cahyana et al., (2017) in that mobile learning has a positive effect on the learning outcomes of chemistry in groups of students who have high independence.

Based on the analysis, instructional media has helped to convey information or lessons with the aim of stimulating students to learn. Learning media can overcome the limitations of space and time in learning, they can also motivate students to learn. In addition, mobile learning as a visual media has encouraged students’ high-level thinking skills, and, as stated by Ealy (2015), that higher-order thinking skills can be stimulated by using visual media. So, the use of learning media will provide stimulus to improve students’ thinking skills. In addition, student learning motivation influences students’ thinking processes in learning, so that with learning media and learning motivation students will influence their thinking skills towards more complex ones (HOTS). The results also shows that higher order thinking skills of students who use mobile learning are higher than students who use PowerPoint media. This is relevant to Miller (2017) in that students are more confident in their learning because the use of mobile devices has increased their interest and motivation compared to learning from textbooks. PowerPoint media used in classrooms is more teacher-centered, which causes students to be passive in learning. Students only receive sources of information from teachers, which causes students to lack motivation and excitement. Therefore, in this study, students feel more excited and motivated to learn when using mobile devices. The study also found that mobile learning is suitable for students who have high learning motivation. This is because mobile learning provides an advantage to be used anytime and anywhere so that students can gain knowledge in a more in-depth and comprehensive manner, and it can also improve student learning motivation. Learning motivation has the potential to influence what, when and how to learn, and increase the likelihood of being involved in activities that
will help students to learn and achieve better performance, and consequently will result in higher level thinking skills. This is relevant to the study by Ciampa (2013), which shows that motivation can be improved through challenges, curiosity, control, recognition, competition and co-operation. Therefore, mobile learning can greatly help to increase student motivation. Students with low learning motivation tend to be passive learners and follow the learning process as the teacher says, so students who have this attitude may find it easier to master the lesson. The learning material delivered by the teacher must be structured and systematic. So the learning process with PowerPoint media seems more profitable for students who have low learning motivation. This study has limitations that only use learning media and the study of learning motivation for students' high-level thinking skills. This can be further developed based on the focus of various levels of motivation.

4 CONCLUSION

The use of mobile learning has a positive effect on improving students' higher order thinking skills (HOTS). Students can access material or information wherever and whenever as they are not bound by space and time. Learning materials contained in mobile learning is interesting because it is equipped with games, animations, quiz questions, and learning videos, so that it can increase learning motivation and provide a stimulus to students in learning so that students could be trained to think at higher levels.

Based on the results obtained, the use of mobile learning has a positive effect when applied to a group of students who have high learning motivation. For example, in groups of students who have low learning motivation, when using mobile learning, there is no effect on their HOTS. Thus the use of mobile learning in chemistry learning will provide positive results when applied to groups of students who have high learning motivation. The condition is also supported by research findings, that there is an interaction between mobile learning and learning motivation toward HOTS of students.

REFERENCES


