THE ONLINE LABORATORY SIMULATION WITH CONCEPT MAPPING AND PROBLEM BASED LEARNING (OLS-CMPBL): IS IT EFFECTIVE IN IMPROVING STUDENTS' DIGITAL LITERACY SKILLS?

Riki Perdana*, Jumadi Jumadi, Dadan Rosana, Riwayani Riwayani
Yogyakarta State University, Indonesia
*e-mail: jumadi@uny.ac.id

Abstract: Digital literacy skills of students in Indonesia are still very low. This study aims to examine the effectiveness of Online Laboratory Simulation with Concept Mapping and Problem-Based Learning model in improving students' digital literacy skills. Specifically, the research objectives have been to explore the significant difference between students who learned through the PBL model, Online Laboratory Simulation with Problem-Based Learning (OLS-PBL) model, and Online Laboratory Simulation with Concept Mapping and Problem-Based Learning (OLS-CMPBL) model. It is a quasi-experimental with pre and post-test design. The population of this research is students at Islamic State School Yogyakarta (MAN), Indonesia. There were 97 students of class XI science at Islamic State School 1 (MAN 1) as participant. The main data analyses used in this study were the paired-sample t-test, comparative-descriptive analysis, and ANOVA mixed design using SPSS 24. The study reveals that (1) The OLS-CMPBL group had a significant difference in the level of digital literacy skills (*sig* .0000); (2) the OLS-CMPBL was the most effective model to improve the skills with a gain score of .207 (low). Learning with the OLS-CMPBL model can be an alternative for policymakers and teachers to solve the problems of digital literacy.

Keywords: online laboratory simulation, concept mapping, PBL, digital literacy

MODEL *ONLINE LABORATORY SIMULATION WITH CONCEPT MAPPING AND PROBLEM BASED LEARNING (OLS-CMPBL):* APAKAH EFEKTIF DALAM MENINGKATKAN KETERAMPILAN LITERASI DIGITAL SISWA?

Abstrak: Keterampilan literasi digital siswa di Indonesia masih sangat rendah. Penelitian ini bertujuan untuk menguji efektivitas model *Online Laboratory Simulation with Concept Mapping and Problem-Based Learning* dalam meningkatkan keterampilan literasi digital siswa. Tujuan penelitian adalah menggambarkan signifikansi perbedaan antara siswa yang belajar menggunakan model *Problem-Based Learning* (PBL), model *Online Laboratory Simulation with Problem-Based Learning* (OLS-PBL), model *Online Laboratory Simulation with Concept Mapping and Problem-Based Learning* (OLS-CMPBL) dan efektivitas model-model pembelajaran tersebut. Penelitian ini merupakan penelitian eksperimen semu dengan desain pre-test dan post-test. Populasi penelitian adalah siswa di sekolah Madrasah Aliyah Negeri (MAN) Yogyakarta. Ada 97 siswa kelas XI sains di MAN 1 Yogyakarta sebagai peserta dalam penelitian ini. Teknik analisis data menggunakan *paired-sample t-test*, analisis komparatif-deskriptif, dan *ANOVA mixed design* menggunakan program SPSS 24. Hasil penelitian mengungkapkan bahwa: (1) kelompok OLS-CMPBL memiliki perbedaan yang signifikan dalam tingkat keterampilan literasi digital (*sig* .0000); (2) OLS-CMPBL paling efektif untuk meningkatkan keterampilan literasi digital siswa dengan skor gain 0,207 (rendah). Pembelajaran dengan model OLS-CMPBL dapat menjadi alternatif bagi pembuat kebijakan dan guru untuk memecahkan masalah keterampilan literasi digital.

Kata Kunci: online laboratory simulation, concept mapping, PBL, literasi digital

INTRODUCTION

At present, everything can be done using information technology and communication tool (Klimov, 2012). One application of technology is in the learning process such as the in-corporation of online tools into face-to-face or traditional teaching approaches (Brown, 2016). Online learning is quite easy to apply in the learning process in various fields (Gercek, Saleem, & Stee, 2016). The majority of students respond

that online learning increases their interest and encourages them to develop independent learning skills. Besides, they experience a better understanding of the subject and a higher level of interaction with the teacher. The application of technology in learning can improve student activity and stimulate the learning process and provide a more collaborative learning experience (Okaz, 2015).

The use of internet technology to improve learning models has attracted the attention of many researchers (Asraf, Dalila, Zakiah, Faiz, & Nooritawati, 2018). Students need technology and information skills to help investigate and solve problems in learning. Digital literacy skills are very important for students so that they can use information technology effectively in learning. Digital literacy can provide the basics of managing the digital environment that students need to succeed in information literacy and their fields of study (Cordell, 2013). However, the digital literacy level of educated students in learning is still relatively low (Rahayu & Mayasari, 2018). In this case, the skills in understanding and utilizing various in-formation from digital sources are also defined as digital literacy (Bulger, Mayer, & Metzger, 2014), it is important to be improved in education.

Web-based and e-learning has become an interesting and promising method in the learning process due to an increase in internet capabilities (Christ & Thews, 2016). Simulation-based learning allows users to access various types of simulations according to their respective disciplines (Ma, Lee, Cho, & Suh, 2019). Online simulation learning can improve students' understanding of content knowledge (Lamb, 2014). The use of simulations also allows students to experience the scientific reality that is not possible directly (Lamb, 2016). Simulation not only visualizes extracted and complex scientific phenomena, but also provides opportunities for students (Shen, Jiang, & Liu, 2015). Thus learning using simulation can help students understand concepts that are difficult to visualize.

Simulation is a process that produces a prototype application using a conceptual model as its input (Sedrakyan, Snoeck, & Poelmans, 2014). Students who interact with virtual simu-lations provide opportunities to observe scientific models to build an understanding of a concept (Thacker & Sinatra, 2019). Online simulations can focus on real-world connections using objects that are known to bridge scientific concepts and real-life experiences (Zhang, 2014). Simulation can display representative results in the form of dynamic graphs that represent a concept (Langbeheim & Levy, 2019). If in simulation lessons, the teacher presents a digital environment with complex graphics, students will also think of similar concepts in the real world (Howard, 2017). Traditional learning especially in laboratory activities can be improved through computer simulations (Rutten, van Joolingen, & Van Der Veen, 2012). It is increas-ingly being applied as a tool to improve problem-based learning in science education (Liu, Cheng, & Huang, 2011).

High-level thinking skills such as analytical thinking, reflective, synthesis, critical and other skills can be trained and developed through concept maps (Cañas, Reiska, & Möllits, 2017). Concept maps have been used to develop thinking skills and build understanding as a tool to map the mindset acquired to become a new under-standing (Heron, Kinchin, & Medland, 2018). Concept mapping is related to meaningful learning theory which shows that new knowledge is acquired when most are related to the existing knowledge framework (Omeiza, 2019). Concept maps made by students involve several activities such as (1) Understanding the main concepts presented in both audio and visual learning; (2) Identifying relationships be-tween concepts; and (3) Describing the relationship between concepts using descriptive labels (Liu, Kim, & Wang, 2018). Concept maps show the relationship between two or more concepts through node diagrams on each node that represent a particular concept (Schroeder, Nesbit, Anguiano, & Adesope, 2018). It was made by students express their understanding of information that is related to their previous knowledge (Reiska, Soika, & Cañas, 2018).

Problem-based learning (PBL) has been used extensively in many fields of education that focuses on critical thinking and problem solving (Yew & Goh, 2016). PBL can be applied to many topics and successfully implemented in various fields of education (Loyens, Jones, Mikkers, & van Gog, 2015). PBL has been proven as an appropriate way of learning and is liked by teachers and students to improve learning

outcomes (Syamsuddin, 2016). The important thing in the PBL model is the role used to facilitate students in the learning process delivered by the teachers (Saleh, Silver, Chen, Shanahan, Rowe, & Lester, 2018). Activities that are focused on investigating learning outcomes and exploring motivational factors can help in understanding the PBL context (Bergstrom, Pugh, Phillips, & Machlev, 2016). The application of PBL in the learning process is very important, has the opportunity for adaptation and integration in the world of students that must be continuously developed (Gorghiu, Drăghicescu, Cristea, Petrescu, & Gorghiu, 2015).

In PBL, students utilize their knowledge in order to actively participate in the learning process according to the topic of learning as opposed to passive learning, based on lectures and instructions designed by the teacher (Zahid, Varghese, Mohammed, & Ayed, 2016). This model consists of giving problems to students so that they can learn about a particular domain by developing solutions to solve the problem (Lozano, Gracia, Corcho, Noble, & Gómez-Pérez, 2015). This model emphasizes the importance of affective, cognitive and psychomotor to achieve student learning achievement (Demirel & Dağyar, 2016). The purposes of this study is describing the significances of the difference between learned students using the OLS-CMPBL, OLS-PBL, and PBL models, and the effectiveness of these learning models in improving students' digital literacy skill. However the OLS-CMPBL model has never been aplied or previously applied to the teaching in the class. In addition, according to Le, Woods, Wang, & Lawrie (2019) the students' digital literacy skill is still very low. Therefore, a learning model is needed that can enhance the learning process especially in digital literacy skill.

METHODS

This study was quasi-experimental which is the objective was observing the digital literacy skill of students using PBL, OLS-PBL and OLS-CMPBL. This OLS-CMPBL model, however, is the new learning model and has not been applied at the class. The research design was Pre-test and Post-test Control Group Design. The aim of the research was to know the students' digital literacy skills between the OLS-CMPBL and OLS-PB model as the experimental groups and PBL model as the control group. The first competency of all groups would be the same with the homogeneity test of the variance from the pre-test data of each group. Hence, these research objectives have been describing the significances of the difference between learned students using PBL, OLS-PBL, and OLS-CMPBL and the effectiveness of all models.

There were 97 science students grade XI (15 – 16 age) from Islamic State School (Madrasah Aliyah Negeri/MAN) 1 Yogyakarta as partisipants in this study. Random sampling technique was used from three Islamis State School (MAN 1, MAN 2 and MAN 3) in Yogyakarta. There are two classes for the OLS group. The first class was only taught with OLS-PBL model learning which consisted of a total of 32 (16 males and 16 females) students. The second class was based on the OLS-CMPBL learning model consisting of a total of 33 (16 males and 17 females) students. The third class is only taught with the PBL model consisting of 32 (16 male and 16 female). All classes are given six sessions, and each session consists of 60-90 minutes.

The research tools used are (1) PBL, OLS-PBL, and OLS-CMPBL matrices that contain learning competencies based on topics, activities and assessments given to students during the study period. It has been validated by professional expert; (2) Guide-lines for Teachers which consist of detailed lesson plans. This serves as a guide for teachers to convey to students learning PBL, OLS-PBL, and OLS-CMPBL; (3) Learning Materials in the form of other modules developed by researchers. Each module includes several lessons for students, who instruct students to use digital devices to freely search for information and experiment with virtual devices; (4) Test digital literacy skills. Students are asked to complete 10 questions according to aspects of digital literacy skills. The items are also validated by professional experts and empirical test. For the professional judgment we used content validity ratio (CVR) according to (Lawshe, 1975). For the empirical test, we got the validity and reliability scale. Based on the QUEST result, all items was valid with the reliability scale .96. Assessment of student skills based on the rubric using levels 0 – 4. Table 1 shows the skill level of students based on their

test results according to (Valdez & Bungihan, 2019).

Table 1. Level of Students Skill

Range	Level
0 – .49	Very low
.50 – 1.49	Low
1.50 – 2.49	Average
2.50 – 3.49	High
3.50 – 4.00	Very high

All students were given 10 pre-test and post-test. The results were used to identify the level of students' digital literacy skills after they were exposed to the three different models. At first, we prepared 14 questions based on the aspects of students' digital literacy skills according to Lankshear & Knobel (2008). These aspects include: a) Internet searching, b) Hyper textual navigation, c) Content evaluation, d) Knowledge assembly. There was a professor, two doctors, two professional teachers, and two postgraduate students assessed all of items. After the material assessment and based on expert recommendations, the final question is reduced to 10 as shown as in Table 2.

Table 2. The Items of Digital Literacy Skill

Item	Aspect of Digital Literacy Skill
1,2	Internet searching
3,4,5	Hyper textual navigation
6,7,8	Content evaluation
9,10	Knowledge assembly

In this study, we used SPSS 24 to analyze data. The profile of students' skills was analyzed by descriptive statistics. Analyzes were performed using paired sample *t-tests* on the results of tests conducted by students to determine differences in the quality of their digital literacy skills. ANOVA analysis of mixed designs was used to determine differences in the results of digital literacy skills in the PBL, OLS-PBL and OLS-CMPBL groups. Finally, to determine the effectiveness level of each model, we use the gain score analysis with Hake's equation (Hake, Wakeland, Bhattacharyya, & Sirochman, 1994):

$$\text{Gain (g)} = \frac{\overline{X}_{\text{posttest}} - \overline{X}_{\text{pretest}}}{\text{maximum score} - \overline{X}_{\text{pretest}}}$$

Where $\overline{X}_{posttest}$ and the $\overline{X}_{pretest}$ is the average score from the pre and post-test. Level of effectiveness is based on the above equation as shown in Table 3.

Table 3. Gain score

Gain	Level of Effectiveness
$g < .3$	Low
$.7 > g \geq .3$	Medium
$g \geq .7$	High

FINDINGS AND DISCUSSION

Findings

According to Langub & Lokey-Vega (2017) digital literacy is an important aspect to consider in education to facilitate the needs of twenty-first-century learners. These skills become agents of central empowerment in educational institutions because work and personal life are becoming increasingly technological, including for the teachers themselves (White, 2015). Therefore, students' skills in digital literacy need to be improved during the learning process.

PBL Group

Students were given 10 questions based on four aspects of digital literacy skills. Table 4 shows the results of their answers and their skill level. It shows that students' level in this group showed very low levels of digital literacy skills. These results show that their skills related to digital literacy have not been improved. The quality of students in PBL Group before and after learning is shown in Table 5. Paired sample t-test is used to see whether there are significant differences in digital literacy skills before and after the learning process as shown in Table 6.

OLS-PBL Group

Students were given 10 questions based on four aspects of digital literacy skills. Student answers are analyzed and the results are shown in Table 7. Table 7 shows that students in the OLS-PBL group showed the quality of students' skills. The level of students' digital literacy skills in OLS-PBL Group before and after they were taught with this model is shown in Table 8. Paired sample t-test was used to determine differences in the results of digital literacy skills in this group. The results are shown in Table 9.

Table 4. The Students' Level in PBL Group

Aspect of DL Skills	Pre-test		Description	Post-test		Description
	Mean	*SD*		Mean	*SD*	
Internet searching	1.38	.46	Low	1.50	.37	Average
Hyper textual navigation	.75	.79	Low	1.92	.71	Average
Content evaluation	1.04	1.31	Low	2.00	1.22	Average
Knowledge assembly	.63	1.77	Low	.88	1.71	Low
Overall	.93	.50	Low	1.65	.52	Average

Note: 0 – .49 = 'Very low'; .50 – 1.49 = 'Low'; 1.50 – 2.49 = 'Average'; 2.50 – 3.49 = 'High'; 3.50 – 4.00 = 'Very high'

Table 5. Level of Digital Literacy Skill of the PBL Group before and after Learn with PBL Model

Level of DL Skills	Before (*N* = 32)		After (*N* = 32)	
	f	%	*f*	%
Very low	11	34.375	3	9.375
Low	11	34.375	5	15.625
Average	10	31.25	21	65.625
High	0	0	3	9.375
Very high	0	0	0	0
Overall	Mean = .93 (Low), *SD* = .80		Mean = 1.65 (Average), *SD* = .71	

Note: 0 – .49 = 'Very low'; .50 – 1.49 = 'Low'; 1.50 – 2.49 = 'Average'; 2.50 – 3.49 = 'High'; 3.50 – 4.00 = 'Very high'

Table 6. Paired Sample t-test Analysis of The Digital Literacy Skill of PBL Group

	Mean	*SD*	*t-value*	*df*	*Sig*
Pre-test	.93	.80	-4.751	31	.000
Post-test	1.65	.71			

Table 7. The Students' Level in OLS-PBL Group

Aspect of DL skills	Pre-test		Description	Post-test		Description
	Mean	*SD*		Mean	*SD*	
Internet searching	1.63	.41	Average	1.81	.30	Average
Hyper textual navigation	1.08	.78	Low	1.67	.68	Average
Content evaluation	1.96	1.26	Average	2.33	1.16	Average
Knowledge assembly	1.75	1.72	Average	1.25	1,63	Low
Overall	1.58	.50	Average	1.81	.51	Average

Note: 0 – .49 = 'Very low'; .50 – 1.49 = 'Low'; 1.50 – 2.49 = 'Average'; 2.50 – 3.49 = 'High'; 3.50 – 4.00 = 'Very high'

Table 8. Level of Digital Literacy Skill of the OLS-PBL Group before and after Learning Process

Level of DL Skills	Before (*N* = 32)		After (*N* = 32)	
	f	%	*f*	%
Very low	7	21.875	1	3.125
Low	1	3.125	2	6.25
Average	22	68.75	28	87.5
High	2	6.25	1	3.125
Very high	0	0	0	0
Overall	Mean = 1.58 (Average), *SD* = .90		Mean = 1.81 (Average), *SD* = .47	

Note: 0 – .49 = 'Very low'; .50 – 1.49 = 'Low'; 1.50 – 2.49 = 'Average'; 2.50 – 3.49 = 'High'; 3.50 – 4.00 = 'Very high'

Table 9. Paired Sample t-test Analysis of the Digital Literacy Skill of OLS-PBL Group

	Mean	*SD*	*t-value*	*df*	*Sig*
Pre-test	1.58	.90	-1.567	31	.127
Post-test	1.81	.47			

OLS-CMPBL Group

Students were given 10 questions based on four aspects of digital literacy skills. Student answers are analyzed and the results are shown in Table 10. The quality of digital literacy that are still very low in the OLS-CMPBL group. It shows that their skills related to digital literacy have not been improved. The level of students' digital literacy skills in OLS-CMPBL Group before and after they were taught with this model is shown in Table 11. Paired sample t-test was used to determine differences in the results of digital literacy skills in this group as shown in Table 12.

Comparison of All Group

In this study, we use ANOVA Mixed Design to determine the greatest influence between PBL, OLS-PBL, and OLS-CMPBL learning on students' digital literacy skills. The results as shown as in Table 13. A comparison of all groups was also analyzed using the gain score. The results are presented in Table 14. It shows that there is an increase in all groups. But, the level of effectiveness of all groups is still low.

Table 10. The Students' Level in OLS-CMPBL Group

Aspect of DL skills	Pre-test		Description	Post-test		Description
	Mean	*SD*		Mean	*SD*	
Internet searching	1.64	.41	Average	1.94	.29	Average
Hyper textual navigation	1.29	.46	Low	2.87	.23	High
Content evaluation	1.49	.43	Low	2.30	.37	Average
Knowledge assembly	.67	.37	Low	.18	.20	Very low
Overall	1.30	.06	Low	1.98	.53	Average

Note: 0 – .49 = 'Very low'; .50 – 1.49 = 'Low'; 1.50 – 2.49 = 'Average'; 2.50 – 3.49 = 'High'; 3.50 – 4.00 = 'Very high'

Table 11. Level of Digital Literacy Skill of the OLS-CMPBL Group before and after Learning Process

Level of DL Skills	Before (N = 33)		After (N = 33)	
	f	%	*f*	%
Very low	3	9.09	1	3.03
Low	16	48.48	1	3.03
Average	14	42.42	28	84.84
High	0	0	3	9.09
Very high	0	0	0	0
Overall	Mean = 1.58 (Average), *SD* = .90		Mean = 1.81 (Average), SD = .47	

Note: 0 – .49 = 'Very low'; .50 – 1.49 = 'Low'; 1.50 – 2.49 = 'Average'; 2.50 – 3.49 = 'High'; 3.50 – 4.00 = 'Very high'

Table 12. Paired Sample t-test Analysis of the Digital Literacy Skill of the OLS-CMPBL Group

	Mean	*SD*	*t-value*	*df*	*Sig*
Pre-test	1.29	.62	-4.782	32	.000
Post-test	1.98	.52			

Table 13. Anova Mixed Design Analysis of All Group

Group	*Sig*	Partial Eta Square
PBL (*N* = 32)	.000	.202
OLS-PBL (*N* = 32)	.126	.025
OLS-CMPBL (*N* = 33)	.000	.192

Table 14. Effectiveness of All Group based on Gain Score

Group	Mean of Pre-test	Mean of Post-test	Gain Score	Description
PBL (*N* = 32)	.93	1.65	.199	Low
OLS-PBL (*N* = 32)	1.58	1,81	.004	Low
OLS-CMPBL (*N* = 33)	1.29	1.98	.207	Low

Note: $g < .3$ = "Low", $.30 \leq g \leq .70$ = "Medium"; $g > .70$ = "high"

Discussion

The mean of the digital literacy skills of students in PBL group before learning process was low (mean = .93, *SD* = .50). Among 10 questions given, the lowest student answers are in aspect knowledge assembly with mean = .63 (low). Meanwhile, the highest average score of student answer is aspect content variation 1.38 (low). The digital literacy skills in the PBL group was at a very low and low level (34.75%) before the learning process. In general, based on the pre-test results students in this group had low levels (mean = .93; *SD* = .80). There are no students showed a higher level.

The quality of digital literacy skills based on post-test score was at average level (mean = 1.65; *SD* = .71). In particular, most (65.625%) students showed average levels of digital literacy skills, and only (9.375%) at the high level. It should be considered that there is a decrease in the number of students at low and very low levels and an increase in the number of students at the average amd high level. Overall, PBL models can improve students' achievement. There are differences in the average value of .72 points (pre and post-test) and there are significant differences based on the results of the analysis with paired sample t-test.

For the OLS-PBL group the mean of the digital literacy skills of students was average level (mean = 1.58, *SD* = .50) in pre-test. Among 10 questions given, the lowest student answers are in aspect hyper textual navigation with mean = 1.08 (low). Meanwhile, the highest student answer is aspect content variation (mean = 1.96) still at average level. The quality of digital literacy skills that are still average level in the OLS-PBL group shows that their skills related to digital literacy have not been improved.

The quality of digital literacy skills in the OLS-PBL group was at a very low level (21.875%) and few (3.125%) of students showed a low level and only (6.25%) at high level before learning process. In general, students in this group had average levels (mean = 1.58; *SD* = .90) based on pre-test score. There are two students at high level. Also, the quality of students' digital literacy skills after learning process with OLS-PBL model was at average levels (mean = 1.81; *SD* = .47).

In particular, most (87.5%) students showed average levels of digital literacy skills, few (6.25%) of them showed low levels and only (3.125%) at the high level. It should be considered that the there is a decrease in the number of students at high and low level. However, there has been an increase in the number of students at average levels. But, there are no significant differences about digital literacy skills in OLS-PBL group. Although there are differences in the average value of .23 points (pre and post-test), the significant value .127 > .005. It shows that OLS-PBL learning does not help in increasing the quality of digital literacy skills.

For the OLS-CMPBL group, before learning process, students in this group showed low levels of students' digital literacy skill. The mean of the digital literacy skills of students is only low level (mean = 1.30, *SD* = .06). Among 10 questions given, the lowest student answers are in aspect knowledge assembly with mean = .67 (low). Meanwhile, the highest student answer is aspect internet searching (mean = 1.64) at average level.

Before learning process, the quality of students' digital literacy skills in the OLS-

doi:10.21831/cp.v39i2.31491

CMPBL group was at a low (48.48%) and very low level (9.09%). Only few students (42.42) showed average level. In general, students in this group had low levels (mean = 1.30; *SD* = .62) based on the pre-test score. There are no students at high level. The quality of students' digital literacy skills after learning process with OLS-CMPBL model was at average levels (mean = 1,98; *SD* = .52).

After learning process, most (84.84%) students showed average levels of digital literacy skills, few (9.09%) of them showed high levels and only (3.03%) at the low and very low level. It should be considered that there is an increase in the number of students at the low and average level. Overall, there has been a decrease in the number of students at average and high levels. There are significant differences about digital literacy skill in OLS-CMPBL group. The table shows that there are difference in the average value of .69 points (pre and post-test). It indicates that the OLS-CMPBL model used significantly helped in improving their level.

For the comparison of three learning models in this study, as stated by (Leech, Barret, & Morgan, 2005), the meaning of PES: PBL model can enhance the students' digital literacy skills by 20.2%, OLS-PBL model = 2.5% and OLS-CMPBL = 19.2%. The result indicates that the PBL model is the most effective to enhance students' digital literacy skills than OLS-PBL and OLS-CMPBL. Also, OLS-CMPBL is more effective than OLS-PBL to enhance student's digital literacy skills. The biggest increase of the PBL and OLS-CMPBL Group can because students in this class have a lower level of digital literacy skills than OLS-PBL. This can be proven in the graph of changes in student skills (see Figure 1). We can see that students in the PBL-OLS have the highest initial ability, followed by PBL-CMPBL and PBL group. The OLS-CMPBL group is the highest with a gain score of .207 (low) in enhancing students' digital literacy skills. This is because they are accustomed to learning to use digital devices. Besides, they were also asked to make concept maps according to the information found in the learning process. The PBL group is higher than OLS-PBL with a gain score of .199 (low). When learning with digital devices, they are not taught what skills they must possess. Students only apply learning according to the module without direction, unlike the OLS-CMPBL class taught to make concept maps.

According to the finding of this research, the quality of digital literacy skills before learning process is very low for all groups. The effectiveness of OLS-CMPBL, OLS-PBL, and PBL models is at a low level in improving students' digital literacy skills. But, in this study, the OLS-CMPBL model is the most effective model to enhance these skills, followed by PBL and OLS-PBL models. All indicators of digital literacy skills that measured also increase. These indicators include internet searching, knowledge assembly, content evaluation and hyper textual navigation.

It indicates that the PBL model used in teaching this group helped in improving their skills in digital literacy. It is better than the

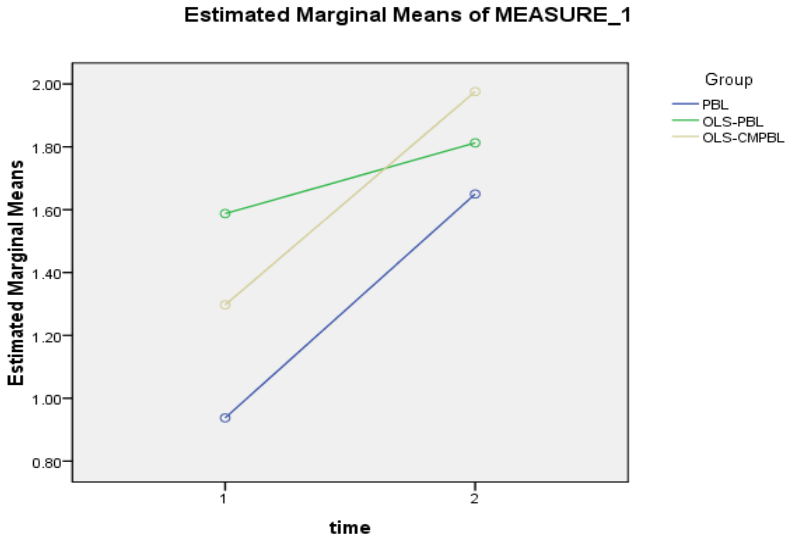

Figure 1. Student Skill before and after Learn of All Group

conventional model in developing knowledge (Aryulina & Riyanto, 2016) and improving learning process (Riyadi, Prayitno, & Karyanto, 2018). This is because PBL forces students to actively build new knowledge based on their current knowledge in the learning process (Chan & Blikstein, 2018). Also, related to the un-der investigations, contents, and students activities, PBL learning becomes a dynamic process and problem centered learning to solve any cases (Major & Mulvihill, 2017). Following (Ju & Choi, 2017), the PBL model structured based on the aspect of argumentation can guide students to solve problems correctly. To solve problems correctly, PBL can help students using the aspects of internet searching and content evaluation in digital literacy skill.

The result of this study is similar to Chiou, Tien, & Lee (2015) where the memory retention, learning achievement and learning satisfaction can be improved by the multimedia animation situation and concept maps learning. E-learning or simulation learning has several advantages in case of accessibility, flexibility, cheapness, and preciseness (Dwijonagoro & Suparno, 2019). It facilitates students to have the strength or ability to be able to explore or search for, deepen, and expand the material they learn through various learning resources online (Divayana, 2017). It is the basic reason why this method can improve the students digital literacy skill.

The application of integrated concept mapping with technology provides benefits such as easy storage, manipulation, conversion, restructuring, comment, dynamic linking, highlight-ing, and present ability (Aşiksoy, 2019). By working together using simulations, students can solve problems together so they can support multiple interaction spaces (Chang *et al*., 2017). Concept mapping also improves the efficiency of computer-assisted simulation techniques in learning environments because it allows learners to deal with an in depth analysis rather than keeping more information which is transferred through lecture based teaching (Hassanzadeh, Hatami, Latifi, Farrokhnia, & Saheb, 2016). Then, based on the analysis of all this theory, the integrated of online simulation, concept mapping and problem based learning (OLS-CMPBL) is effective in improving students'digital literacy skill.

CONCLUSION

The result of data analysis showed that the OLS-CMPBL learning model was more powerful in improving student's digital literacy skills than the OLS = PBL and PBL learning model. Based on the results of study conducted in 2 stages of testing (pre-test and post-test), the OLS-CMPBL is able to stimulate students in hyper textual navigation and content evaluation skill in digital literacy. The OLS-CMPBL learning model can be regarded as the solution to solve the problems of students' digital literacy skills. Hence, the final results of the study indicate that there is a significant difference (*sig* .000) between the OLS-CMPBL and PBL groups. In addition, the OLS-CMPBL model had also proven to be effective for teaching digital literacy skill which shows a significant difference (*sig* .000) between the pretest and post-test.

ACKNOWLEDGMENT

This research was supported by the Indonesian Ministry of Education and Higher Education and the Postgraduate Program of Yogyakarta State University.

REFERENCES

Aryulina, D. & Riyanto, R. (2016). A problem-based learning model in biology education courses to develop inquiry teaching competency of preservice teachers. *Cakrawala Pendidikan, 1*(1), 47-57. doi:10.21831/cp.v1i1.8364.

Aşiksoy, G. (2019). Computer-based concept mapping as a method for enhancing the effectiveness of concept learning in technology-enhanced learning. *Sustainability*, *11*(4), 1-19. doi:10.3390/su11041005.

Asraf, H. M., Dalila, K. A. N., Zakiah, M. Y., Faiz, Z. A., & Nooritawati, M. T. (2018). Computer assisted e-laboratory using LabVIEW and internet-of-things platform as teaching aids in the industrial instrumentation course. *International Journal of Online and Biomedical Engineering, 14*(12), 26-42. doi:10.3991/ijoe.v14i12.8992.

Bergstrom, C. M., Pugh, K. J., Phillips, M. M., & Machlev, M. (2016). Effects of problem-

based learning on recognition learning and transfer accounting for GPA and goal orientation. *Journal of Experimental Education, 84*(4), 764-*786*. doi:10.1080/00220973.2015.1083521.

Brown, M. G. (2016). Blended instructional practice: A review of the empirical literature on instructors' adoption and use of online tools in face-to-face teaching. *Internet and Higher Education, 31*(October), 1-10. doi:10.1016/j.iheduc.2016.05.001.

Bulger, M. E., Mayer, R. E., & Metzger, M. J. (2014). Knowledge and processes that predict proficiency in digital literacy. *Reading and Writing, 27*(9), 1567-1583. doi:10.1007/s11145-014-9507-2.

Cañas, A. J., Reiska, P., & Möllits, A. (2017). Developing higher-order thinking skills with concept mapping: A case of pedagogic frailty. *Knowledge Management and E-Learning*, *9*(3), 348-365. doi:10.34105/j.kmel.2017.09.021.

Chan, M. M., & Blikstein, P. (2018). Exploring problem-based learning for middle school design and engineering education in digital fabrication laboratories. *Interdisciplinary Journal of Problem-Based Learning, 12*(2), 1-13. doi:10.7771/1541-5015.1746.

Chang, C. J., Chang, M. H., Chiu, B. C., Liu, C. C., Fan Chiang, S. H., Wen, C. T., … Chen, W. (2017). An analysis of student collaborative problem solving activities mediated by collaborative simulations. *Computers and Education, 114*(2017), 222-235. doi:10.1016/j.compedu.2017.07.008.

Chiou, C. C., Tien, L. C., & Lee, L. T. (2015). Effects on learning of multimedia animation combined with multidimensional concept maps. *Computers and Education, 80*(2015), 211-223. doi:10.1016/j.compedu.2014.09.002.

Christ, A. & Thews, O. (2016). Using numeric simulation in an online e-learning environment to teach functional physiological contexts. *Computer Methods and Programs in Biomedicine, 127*(2016), 15-23. doi:10.1016/j.cmpb.2016.01.012.

Cordell, R. M. (2013). Information literacy and digital literacy. *Communications in Information Literacy, 7*(2), 177-183. https://files.eric.ed.gov/fulltext/EJ1089065.pdf.

Demirel, M. & Dağyar, M. (2016). Effects of problem-based learning on attitude: A metaanalysis study. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(8), 2115-2137. doi:10.12973/eurasia.2016.1293a.

Divayana, D. G. H. (2017). Evaluasi pemanfaatan e-learning menggunakan model CSE-UCLA. [Evaluation of e-learning utilization using CSE-UCLA model]. *Cakrawala Pendidikan, 36*(2), 280-289. doi:10.21831/cp.v36i2.12853.

Dwijonagoro, S. & Suparno, S. (2019). Pranatacara learning: Modeling, mind mapping, e-learning, or hybrid learning? *Cakrawala Pendidikan, 38*(1), 156-173. doi:10.21831/cp.v38i1.23034.

Gercek, G., Saleem, N., & Stee, D. J. (2016). Implementing cloud based virtual computer network labs for online education: Experiences from a phased approach. *International Journal of Online Engineering, 12*(3), 70-76. doi:10.3991/ijoe.v12i03.5564.

Gorghiu, G., Drăghicescu, L. M., Cristea, S., Petrescu, A. M., & Gorghiu, L. M. (2015). Problem-based learning - An efficient learning strategy in the science lessons context. *Procedia - Social and Behavioral Sciences, 91*(2015), 1865-1870. doi:10.1016/j.sbspro.2015.04.570.

Hake, R. R., Wakeland, R., Bhattacharyya, A., &, & Sirochman, R. (1994). Assessment of individual student performance in an introductory mechanics course. *AAPT Announcer*, *24*(4), 76.

Hassanzadeh, M., Hatami, J., Latifi, S., Farrokhnia, M. R., & Saheb, T. (2016). Teaching science for understanding:

The positive impact of simultaneous use of concept mapping and computer simulations. *Communications in Computer and Information Science,* 192-202. doi:10.1007/978-3-319-45501-3_15.

Heron, M., Kinchin, I. M., & Medland, E. (2018). Interview talk and the co-construction of concept maps. *Educational Research, 60*(4), 373-389. doi:10.1080/00131881.2018.1522963.

Howard, M. C. (2017). Investigating the simulation elements of environment and control: Extending the Uncanny Valley Theory to simulations. *Computers and Education, 109*, 216-232. doi:10.1016/j.compedu.2017.03.005.

Ju, H., & Choi, I. (2017). The Role of Argumentation in hypothetico-deductive reasoning during problem-based learning in medical education: A conceptual framework. *Interdisciplinary Journal of Problem-Based Learning, 12*(1), 1-18. doi:10.7771/1541-5015.1638.

Klimov, B. F. (2012). ICT versus traditional approaches to teaching. *Procedia - Social and Behavioral Sciences, 7*(2012), 196-200. doi:10.1016/j.sbspro.2012.06.638.

Lamb, R. (2014). Examination of allostasis and online laboratory simulations in a middle school science classroom. *Computers in Human Behavior, 39*(2014), 224-234. doi:10.1016/j.chb.2014.07.017.

Lamb, R. L. (2016). Examination of the effects of dimensionality on cognitive processing in science: a computational modeling experiment comparing online laboratory simulations and serious educational games. *Journal of Science Education and Technology, 25*, 1-15. doi:10.1007/s10956-015-9587-z.

Langbeheim, E., & Levy, S. T. (2019). Diving into the particle model: Examining the affordances of a single user participatory simulation. *Computers and Education, 139*(2019), 65-80. doi:10.1016/j.compedu.2019.05.006.

Langub, L. W., & Lokey-Vega, A. (2017). Rethinking instructional technology to improve pedagogy for digital literacy: A design case in a graduate early childhood education course. *TechTrends, 61,* 322-330. doi:10.1007/s11528-017-0185-1.

Lankshear, C. & Knobel, M. (2008). *Digital literacies: Concepts, policies and practices*. Bern, Switzerland: Peter Lang.

Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology, 28*(4), 563-575. doi:10.1111/j.1744-6570.1975.tb01393.x.

Le, B., Woods, G., Wang, J., & Lawrie, G. (2019, 2-4 October). *Digital literacy skills, student interactivity and academic performance in STEM blended courses.* Paper presented at The Australian Conference on Science and Mathematics Education, The University of Sydney and University of Technology Sydney. https://openjournals.library.sydney.edu.au/index.php/IISME/article/view/13564.

Leech, N., Barret, K. ., & Morgan, G. A. (2005). *SPSS for intermediate statistics: Use and interpretation* (2nd ed). Marwah: Lawrence Erlbaum Associates Publishers.

Liu, C. C., Cheng, Y. B., & Huang, C. W. (2011). The effect of simulation games on the learning of computational problem solving. *Computers and Education, 57*(2011), 1907-1918. doi:10.1016/j.compedu.2011.04.002.

Liu, C., Kim, J., & Wang, H. (2018). Concept scape: Collaborative concept mapping for video learning. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*. Montréal, QC: CHI, pp. 1-12. doi:10.1145/3173574.3173961.

Loyens, S. M. M., Jones, S. H., Mikkers, J., & van Gog, T. (2015). Problem-based learning as a facilitator of conceptual change. *Learning and Instruction, 38*(2015), 34-42. doi:10.1016/j.learninstruc.2015.03.002.

Lozano, E., Gracia, J., Corcho, O., Noble,

R. A., & Gómez-Pérez, A. (2015). Problem-based learning supported by semantic techniques. *Interactive Learning Environments, 23*(1), 37-54. doi:10.1080/10494820.2012.745431.

Ma, J., Lee, S., Cho, K. W., & Suh, Y. K. (2019). A simulation provenance data management system for efficient job execution on an online computational science engineering platform. *Cluster Computing*, *22*(1), 147-159. doi:10.1007/s10586-018-2827-2.

Major, T. & Mulvihill, T. M. (2017). Problem-based learning pedagogies in teacher education: The case of Botswana. *Interdisciplinary Journal of Problem-Based Learning, 12*(1), 1-11. doi:10.7771/1541-5015.1543.

Okaz, A. A. (2015). Integrating blended learning in higher education. *Procedia - Social and Behavioral Sciences, 86*(2015), 600-603. doi:10.1016/j.sbspro.2015.04.086.

Omeiza, I. I. (2019). Effect of concept-mapping strategy on the attitude of senior secondary school students of varied ability levels in Algebra in Kogi State, Nigeria. *ATBU Journal of Science, Technology and Education*, *7*(1), 77-87. http://www.atbuftejoste.com/index.php/joste/article/view/688.

Rahayu, T. & Mayasari, T. (2018, April). *Profil kemampuan awal literasi digital dalam pembelajaran fisika peserta didik SMK Kota Madiun*. [Profile of early digital literacy abilities in learning physics of Madiun City Vocational School students]. Proceeding of Seminar Nasional Quantum, 431-437. http://seminar.uad.ac.id/index.php/quantum/article/view/294.

Reiska, P., Soika, K., & Cañas, A. J. (2018). Using concept mapping to measure changes in interdisciplinary learning during high school. *Knowledge Management and E-Learning, 10*(1), 1-24. doi:10.34105/j.kmel.2018.10.001.

Riyadi, P. I., Prayitno, A. B., & Karyanto, P. (2018). The effectiveness of subject specific pedagogy based on problem-based learning to empower student's ecological literacy. *Cakrawala Pendidikan, 37*(2), 212-222. doi:10.21831/cp.v37i2.15809.

Rutten, N., van Joolingen, W. R., & van Der Veen, J. T. (2012). The learning effects of computer simulations in science education. *Computers and Education, 58*(2012), 136-153. doi:10.1016/j.compedu.2011.07.017.

Saleh, A., Silver, C. H., Chen, Y., Shanahan, K., Rowe, J., & Lester, J. (2018). Scaffolding peer facilitation in computer-supported problem-based learning environments. In J. Kay & R. Luckin (Eds.). *Rethinking learning in the digital age: Making the learning sciences count*, *13th International Conference of the Learning Sciences (ICLS) 2018*, Volume 3. London, UK: International Society of the Learning Sciences, pp. 1831-1834. doi:10.22318/cscl2018.1831.

Schroeder, N. L., Nesbit, J. C., Anguiano, C. J., & Adesope, O. O. (2018). Studying and constructing concept maps: a meta-analysis. *Educational Psychology Review, 30*(2), 431-455. doi:10.1007/s10648-017-9403-9.

Sedrakyan, G., Snoeck, M., & Poelmans, S. (2014). Assessing the effectiveness of feedback enabled simulation in teaching conceptual modeling. *Computers and Education, 78*(2014), 367-382. doi:10.1016/j.compedu.2014.06.014.

Shen, J., Jiang, S., & Liu, O. L. (2015). Reconceptualizing a college science learning experience in the new digital era: A review of literature. In J. M. Spector, D. Ifenthaler, & X. Ge (Eds.), *Emerging Technologies for STEAM Education.* Switzerland: Springer International Publishing, pp. 61-79. doi:10.1007/978-3-319-02573-5_4.

Syamsuddin, I. (2016). Problem based learning on cloud economics analysis using open source simulation. *International Journal of Online Engineering, 12*(6), 4-9. doi:10.3991/ijoe.v12i06.5147.

Thacker, I., & Sinatra, G. (2019). Visualizing the greenhouse effect: Restructuring mental models of climate change through a guided online simulation. *Education Sciences, 9*(1), 1-19. doi:10.3390/educsci9010014.

Valdez, J. E. & Bungihan, M. E. (2019). Problem-based learning approach enhances the problem solving skills in chemistry of high school students. *Journal of Technology and Science Education, 9*(3), 282-294. doi:10.3926/JOTSE.631.

White, J. (2015). *Digital literacy skills for FE teachers.* Exeter, UK: Sage Publication. doi:10.4135/9781473909571.

Yew, E. H. J., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health Professions Education, 2*(2), 75-79. doi:10.1016/j.hpe.2016.01.004.

Zahid, M. A., Varghese, R., Mohammed, A. M., & Ayed, A. K. (2016). Comparison of the problem based learning-driven with the traditional didactic-lecture-based curricula. *International Journal of Medical Education, 7,* 181-187. doi:10.5116/ijme.5749.80f5.

Zhang, M. (2014). Who are interested in online science simulations? Tracking a trend of digital divide in Internet use. *Computers and Education, 76*(2014), 205-214. doi:10.1016/j.compedu.2014.04.001.