ATLANTIS PRESS

Advances in Social Science, Education and Humanities Research, volume 382

5th International Conference on Education and Technology (ICET 2019)

Learning Model and Higher-Order Thinking Skill in Advanced Mathematical Study

Syafri Ahmad
Elementary School Teaching Learning
Universitas Negeri Padang, Indonesia
syafriahmad@fip.unp.ac.id

Ary Kiswanto Kenedi
Elementary School Teaching Learning
Universitas Samudra, Indonesia
arykenedi@gmail.com

Yullys Helsa
Elementary School Teaching Learning
Universitas Negeri Padang, Indonesia
yullys@fip.unp.ac.id

Abstract: The background of this study is the weakness of higher-order thinking skill of elementary education major students. Thus, we need a suitable learning model used to improve the higher-order thinking skill of elementary education major students. The purpose of this study is to determine the effectiveness of problem-based learning, problem-solving and problem-posing in improving the higher-order thinking skill of students of elementary education major. This research uses a factorial design. The sample used in this study is a random sampling technique. The sample includes three classes of fifth-semester students. Three classes apply different learning models. The first class uses a problem-based learning model, the second class uses the problem-solving model and the third class uses the problem posing model. The sample used in this study is 117 students. The result shows that the higher-order thinking skill of students with problem-based learning has a significant difference compared to those with problem posing, but it is not significant as students with problem-solving. This research shows that problem-based learning is the most effective model in improving the ability of higher-order thinking skill of elementary education students compared with problem-solving and problem posing. This study implies that the lecturers of elementary education major can improve the higher-order thinking skill of related students by using problem-based learning.

Keywords: mathematical connection ability, elementary school students, 4.0 industrial revolution

I. INTRODUCTION

Mathematics learning is compulsory learning taught starting from the basic to the higher level of education [1] [2] [3]. Learning mathematics must be continuously done. The purpose of this continuous mathematics learning is to make mathematics learning basic learning to continue learning until a higher level [4]. Mathematics is a universal science which underlies science and technology with other multi-disciplines [5]. Thus, mathematics is a basic object in the development of other sciences, this is why learning mathematics must be carried out continuously.

Learning mathematics becomes mandatory because it connects with everyday life [6]. Mathematics plays a role in carrying the future of individual as mathematics can train the ability to think and take initiative in solving problems in everyday life [7]. Mathematics has two useful development visions for achieving the demand of the future and the present [8]. The first vision aims to direct the learning of mathematics in understanding concepts and ideas to solve problems related to mathematics and other sciences. While the second vision aims to develop the ability to think logically, systematically, critically, and creatively [9]. Therefore, mathematics should be owned by everyone to face and solve all problems encountered in everyday life.

Following the purpose and role of mathematics in developing thinking skill such as critical thinking skill, creative and problem-solving skill, it has a very close relationship with higher-order thinking skill. Thinking ability consists of two parts, namely lower-order thinking skill (LOTS) and higher-order thinking skill (HOTS). LOTS is the ability to solve ordinary problems (in general context) and apply existing concepts [10]. Whereas HOTS is defined as thinking process in retrieving information stored in individual memory and linking it with others to expand information to get various possible answer for the problem from an unusual situation [11].

HOTS is rather the ability to think than the ability to memorize, the ability that requires students to analyze, interpret, argue, synthesize and evaluate in specific situations [12]. Marzano identified that HOTS consisted of 13 skills namely skills of comparing, classifying, inducing, deducing, analyzing errors, constructing supporting facts, analyzing perspectives, abstracting, decision making, investigating, solving problems, discovering experimental inquiry [13]. From the opinion above, it can be concluded that HOTS is a high-level thinking ability not only limited only to memorizing information but rather thinking to find unusual answers from different situations

HOTS generally consist of critical and creative thinking skills [14] [15]. Ennis stated that the ability to think critically is the ability to argue, to think reflectively and to decide what needs to be done and what needs to be trusted [16]. The ability to think critically consists of the ability to utilize concepts, utilize prediction of impact and the ability to solve problems [17]. The ability to use concepts consists of having basic skills, providing explanations and inferring the assumptions needed. The ability to utilize principle consists of the ability to question concepts, analyze concepts, synthesize, relationships between concepts. The ability to predict impacts consists

of determining the effect of assumptions, stringing assumptions and using concepts in a well and balanced manner. The ability to solve problems consists of the ability to find the source of the problem, suspect the cause of the problem, and gather information in solving problems [18].

Creative thinking ability is the ability to develop new ideas and concepts and make connections between them [19]. Creative thinking ability is a process to make someone think of thoughts normally [20]. Students with this ability can answer a variety of problems given [21]. Tanujaya divided critical thinking skills into working on competence, trying something new, thinking divergently, and thinking imaginatively [18]. The ability to work above competence consists of rejecting standard techniques, optimizing knowledge, and having high motivation. The ability to try something new consists of having broad interests, having an optimistic orientation, and enjoying challenges. The ability to think divergently consists of the ability to think freely, develop concepts and modify concepts. The ability to think imaginatively consist of the ability to approach trial and error, have original and new ideas.

The development of HOTS is very important in the learning process. HOTS is a common part of thinking skills that must be trained in all learning processes. Students with higher-order thinking skill will enable students to learn optimally, improve the quality of learning, and reduce problems occur in the learning process [18]. Furthermore, HOTS can train students in developing, connecting, and expanding their thinking not just to remember and memorize but also to develop existing information [20]. Therefore, the teacher must train HOTS students in learning mathematics to achieve the objectives of learning mathematics optimally including at the college level, including elementary education major students who will become elementary school teacher candidates. Elementary education students must be able to develop their HOTS thus when they become a teacher, they can develop HOTS from elementary school students.

However, previous research stated that HOTS of elementary education students is still low. Kenedi stated that the ability of elementary education students is still low, only a few of them is in the medium category [20]. Moreover, Ahmad's research revealed that only 16.67% of elementary education students had HOTS in the medium category, 60% with a low category and 23.33% with a low category [22]. Based on these studies, it can be concluded that the HOTS level of elementary education students is still low. Therefore, the solution to improve HOTS for elementary education students is needed.

One way to improve HOTS is to use a contextual learning model [23]. Contextual learning models that can be implemented are problem-based learning model, problem-solving learning model, and problem posing learning model. The problem-based learning model is suitable to improve HOTS in the learning process [24]. The problem-based learning model is a contextual learning model that becomes a problem as a foundation in the learning process [25].

Krajcik stated that Problem Based Learning is a learning approach that acquires knowledge through teamwork and problem solving using scientific method [26]. Torp and Sage stated that problem-based learning is one of the learning models that help students interact and improve higher-order thinking skill by using ill-structured problems related to the subject area and student center [27]. Problems used as learning are described as unstructured problems and have many problem solutions. It can be concluded that problem-based learning is student-centered learning which makes ill-structured problems the foundation in the learning process. Therefore, problem-based learning is considered suitable for increasing students' HOTS.

The contextual learning model considered capable of increasing HOTS is problem-solving [28]. Problem-solving is a learning model that requires thought processes to find relationships between principles and concepts obtained from learning to solve problems [29]. In problem-solving, students will be trained in thinking, increasing self-confidence and curiosity and getting used to solving existing problems [30]. It can be concluded that problem-solving is a learning model that requires the ability to think in solving problems.

Further, a contextual learning model that can improve thinking skills is a problem-posing model. The problem posing model is a learning model that emphasizes students to form and submit questions based on the information or situation provided [31]. The principle of problem posing is a learning model that makes students reformulate the problem given with the purpose to increase understanding and the teacher facilitates students in solving problems [32] [33]. With students giving/submitting questions, it will create a better understanding of the concepts of the material provided. This activity will make students more critical and creative in shaping their knowledge and ultimately students' understanding of a concept becomes better [34]. It can be concluded that problem posing is a learning model allowing students to ask questions of knowledge given to find solutions to these problems.

Problem-based learning, problem-solving and problem posing are learning models that can be used to improve HOTS. Each model has the characteristics to improve the HOTS. Therefore a hypothesis arises, which learning model is better in increasing the Higher-Order Thinking Skill of Elementary Education Students? Therefore, this study aims to find out which learning model is more appropriate to be used in the learning process at Elementary Education Students to improve Higher-Order Thinking Skill (HOTS).

II. METHOD

This study uses experimental research with factorial design to compare HOTS of Elementary Education students by using three different learning models namely problem-based learning, problem solving and problem posing at different levels of ability (high, moderate and low). Sampling uses a random sampling technique. There are three classes chosen.

The first class as an experimental class and two other classes as control classes. The first class as an experimental class uses a problem-based learning model, while the second class as a control class uses a problem posing model and the third class as a control class uses problem-solving model. The research design can be seen from the Table 1.

TABLE I. THE TABLE OF RESEARCH DESIGN

Group	Subject	Pre-Test	Treatment	Post-Test
Experimental (Problem Based-Learning)	R1	O1	X	O2
Control 1 (Problem Solving)	R2	O2	C1	O2
Control (Problem Posing)	R3	O3	C2	O2

Description:

R1 = Experimental class students using problem-based learning model with a total of 39 students.

R2 and R3 = Control classes students using problem-solving and problem posing learning model with a total of 39 students.

O1 dan O2 = Pre-test and post-test used to measure the HOTS (test results can be divided into low, moderate and high ability)

X = Application of the Problem Based Learning model in the learning process

C1 and C2 = Application of problem-posing and problem-solving models in the learning process

Before the action is implemented using a predetermined learning model, students are grouped based on initial abilities. This initial ability is obtained from the results of previous studies. Each class consists of 13 students with low, moderate and high initial abilities

The research instrument used is a test question aimed at measuring the HOTS of Elementary Education students. The questions used are validity and reliability tests. The validity test and the reliability test are tested on 30 students. Calculation of validity tests and reliability tests uses the SPSS 17.00 application. Based on the validity test, the validity coefficients > 0.30 and the calculation of the reliability test, obtained r 11 of 0.93. Hence, we conclude that the questions used to measure HOTS of elementary education students are valid and very reliable. For the question score, a value of 1 if students answer correctly and a value of 0 if students answer incorrectly. Ability data is determined by the N-gain score. N-gain is determined and grouped based on the student's initial ability. Data analysis used ANOVA and continued with the Tukey test with a significance level of 5%. The analysis uses ANOVA factorial design

The hypotheses in this study are (1) H_{01}: there is no difference in students' HOTS abilities by using different learning models, (2) H_{02}: There are no differences in students' HOTS abilities based on differences in students' initial abilities. (3) H_03: There is no significant interaction between learning models and students' initial abilities in HOTS.

III. RESULT AND DISCUSSION

This study shows that HOTS OF Elementary Education students who use problem-based learning is higher than those who use problem-solving and problem-posing learning models. This can be seen from the value of N-gain in the Table 2.

Table 2 shows the results of the N-gain value from the pretest and post-test of the experimental class and the control class based on the students' initial abilities. The results show that problem-based learning has a higher average N-gain value than the problem solving and problem posing learning model of all levels of students' HOTS ability.

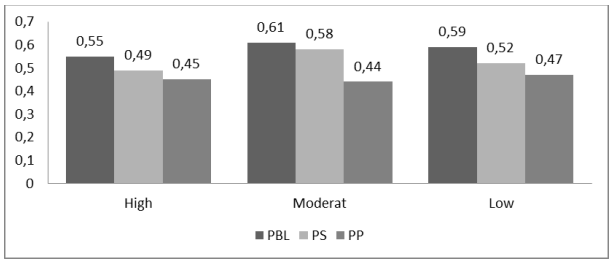

Fig. 1. The N-gain value of the experimental class and control class students in terms of the students' initial abilities (high, moderate, and low)

Furthermore, statistical analysis is performed to determine differences in HOTS ability of students from the three learning models based on initial abilities. Tests carried out by ANOVA statistical analysis can be seen in the table below.

TABLE II. ANOVA ANALYSIS OF STUDENTS' N-GAIN VALUE BASED ON INITIAL ABILITIES AND LEARNING MODELS

Learning Model	Mean Difference	Sig
Learning Model	532.362	.000
Initial Ability	0.917	.401
Interaction Models*Initial Ability	0.421	.784

Table 2 shows the significant differences between the use of learning models (problem-based learning, problem-solving, and problem-posing). Therefore, it is necessary to conduct post hoc test (further test) using the Tukey test. Besides, the results show that there are no significant differences between students with different initial abilities (high, moderate and low), thus there is no need for further test. Also, the calculation results show that there is no significant difference in the interaction between the use of learning models with the initial abilities of students (high, moderate, and low) thus no further tests are needed. The results of further tests (The post hoc test) regarding the use of learning models using the Tukey test can be seen in the Table 3.

TABLE III. THE RESULT OF THE POST HOC TEST

Source	F	Sig
PBL-PS	0,0594	.298
PBL-PP	0,1452	.004
PS-PBL	-0,0594	.298
PS-PP	0,0725	.169
PP-PBL	-0,1452	.004
PP-PS	-0,0725	.169

Based on Table 3, it can be seen that Problem based learning-problem posing has a significant N-gain difference to HOTS of students while the others (problem-based learning-problem solving and problem solving-problem posing) do not have significant N-gain differences. Then, we can conclude that significant N-gain differences occur in the use of problem-based and problem posing learning models. These results indicate that the problem-based learning model is not different from

problem-solving in improving students' Higher-Order Thinking Skills. Nonetheless, the problem-based learning model differs from problem posing, hence further tests must be conducted to determine differences in students' HOTS abilities by using problem-based learning and problem posing. A further test to be done is T-test. The hypothesis in this test is (H0) is "there is no difference in the average HOTS of students with problem-based and problem posing learning model". The T-test results of students using these learning model can be seen in the Table IV.

TABLE IV. THE RESULT OF T-TEST OF STUDENTS USING PBL

Pair	N	Df	T	P
PBL High >< PP High	13	12	1,175	0,258
PBL Medium >< PP Medium	13	12	2,452	0,027
PBL Low >< PP Low	13	12	1,905	0,033

Table 4 Shows that there are significant differences in HOTS of students with medium and low categories on the use of problem-based learning and problem posing. Whereas there is no significant difference in HOTS of high categorized students by using problem-based learning and problem-posing models. This shows that the problem-based learning model can improve students' HOTS abilities rather than the problem posing model with moderate and low categories.

This study shows that the problem-based learning model is more effective in improving the HOTS ability of Elementary Education students in mathematics learning than the problem posing model. However, it does not have differences in results with the problem-solving model especially for students with moderate and low abilities. The results of this study conclude that the problem-based learning model is the most recommended model to be applied in mathematics learning to improve higher-order thinking skills of Elementary Education students.

This research proves that problem as a foundation in the learning process can improve the quality of mathematics learning because it is related to students' daily lives [35]. Learning that begins by presenting a problem in everyday life can stimulate the brain to improve critical and creative thinking skills. This is because problem-based learning requires students to learn from problems in everyday life, with problem-solving will enhance the ability to think as higher-level students. Additionally, students are required to solve problems and analyze problems that exist in everyday life [36].

Based on the classroom observation, it shows the increase in student activity in the process of problem-based learning thus students feel the enthusiasm to practice higher-order thinking skills. This also happens in classes with problem-solving models. While there is no significant student activity in problem posing classes. In problem-based learning, lecturers act as facilitators [37]. Problem-based learning opens opportunities for students to explore all their knowledge and to find information from other learning sources both reading references and other activities that support them independently. This process requires students to search for information critically and creatively to solve the problem.

This study also shows that problem-based learning is attractive to students because students can collaborate in finding solutions to problems. This is because problem-based learning is learning that solves problems cooperatively and collaboratively [38]. This also happens to problem-solving learning. Student activities also increased. Problem-solving knows how to improve student learning activities because the problem solved categorized as a non-routine problem related to student life thus students are required to actively find various strategies in solving these problems [39]. Students are automatically guided to think critically and creatively in solving a problem. Therefore, the research shows that there is no significant difference between problem-based learning and problem solving because both models make problems as a learning process and require students to solve problems critically and creatively. This way can improve their ability to think at a higher level. Yet, problem-based learning is more effective than the problem posing model.

The ineffectiveness of the problem-based learning model compared to the problem-posing model can be seen from the level of motivation and activity of students in the learning process. Based on observation, most students get bored when reading the information presented, then students are demanded to ask questions about problems that occur (in problem posing), even though the problems presented are closely related to everyday problems. Besides, just reading information and finding problems without being connected with other information is less able to train students' ability to think critically and creatively.

In problem-based learning, lecturers only present information without explaining the problem as a whole, and then students are required to find problems from information served by lecturers. Consequently, the students feel motivated to figure this problem out which then cause their activities to increase. Problem-based learning provides ill-structured information where the information only served partly. From this condition, students can develop hypotheses, practice creative thinking skills and obtain solutions [40].

Problem-based learning is very suitable for students with moderate and low-order thinking skill. The increase in HOTS of students with moderate and low abilities is higher than those with problem posing. While the use of problem-based learning and problem posing for students with high HOTS is not much different. This result shows that problem-based learning is more suitable for students with high and low-order thinking skills.

The right learning model will improve the quality of learning [41]. The learning model has a big role in creating a learning atmosphere that will determine the achievement of learning objectives. Slavin stated that a good learning model makes learning atmosphere cooperative, collaborative and use thinking skills [42]. From this, problem-based learning is collaborative, cooperative and requires thinking ability. It can be said that problem-based learning is a good and appropriate learning model used for Elementary Education students in improving Higher-Order Thinking Skills.

IV. CONCLUSION

The researcher concludes that problem-based learning can improve Higher-Order Thinking Skills of Elementary Education students and the same goes to the problem-solving model. Problem-based learning is more effective

than the problem posing model in improving the higher-order thinking skills of Elementary Education students. However, the research also found that problem-based learning is more suitable for students with moderate and low-order thinking skills compared to problem-solving and problem-posing

REFERENCES

[1] A.K Kenedi, Y. Helsa and S. Hendri, "Pengembangan Bahan Ajar Matematika Berbasis Alquran Di Sekolah Dasar," vol.2, no.1, pp. 29-36,2018.

[2] Y. Helsa, "Al-Quran Based Learning Strategy in Teaching Mathematics at Primary Education," vol. 169, no. Icece 2017, pp. 304–306, 2018.

[3] S. Seragih and E. Napitupulu, "Developing Student-Centered Learning Model to Improve High Order Mathematical Thinking Ability," vol. 8, no.6, pp. 104-112,2015.

[4] S. Ahmad, A.K Kenedi and M. Masniladevi, "Instrumen HOTS Matematika Bagi Mahasiswa PGSD," vol. 2, no. 6, pp. 905–912, 2018.

[5] A.K Kenedi and Y. Helsa," Literasi Matematis Dalam Pembelajaran Berbasis Masalah," in *National Conference Pembelajaran Literasi Lintas Disiplin Ilmu Ke-SD-an*, pp.165-174, 2018.

[6] A. K. Kenedi, Y. Helsa, Y. Ariani, M. Zainil, and S. Hendri, "Mathematical Connection of Elementary School Students To Solve Mathematical Problems," vol. 10, no. 1, pp. 69–80, 2019.

[7] S. Hendri and A.K Kenedi," Analisis Pendahuluan Pengembangan Bahan Ajar Matematika Berbasis Discovery Learning Pada Materi Pecahan Untuk Meningkatkan Kemampuan Pemecahan Masalah Siswa Kelas V SD," vol. 2, no.2, pp. 78-89, 2018.

[8] A.K Kenedi, S. Hendri, H.B Ladiva and N. Neliarti," Kemampuan Koneksi Matematis Siswa Sekolah Dasar Dalam Memecahkan Masalah Matematika," vol. 5, no.2, pp. 226-235, 2018.

[9] U. Sumarno. (2010). *Berpikir dan Disposisi Matematik: Apa, Mengapa, dan Bagaimana dikembangkan pada Peserta Didik* [online] available file:///C:/Users/user/Downloads/BERFIKIR_DAN_DISPOSISI_MATEMATIK_APA_MEN.pdf

[10] T. Thompson, "Mathematics Teachers' Interpretation Of Higher-Order Thinking In Bloom's Taxonomy," vol. 3, no. 2, pp.96-109 2008.

[11] D. Polly and L. Ausband, "Developing Higher-Order Thinking Skills through WebQuests," vol. 26, no. 1, pp. 29–34, 2009.

[12] J. L. S. Ramos, B. B. Dolipas, and B. B. Villamor, "Higher Order Thinking Skills and Academic Performance in Physics of College Students : A Regression Analysis," no. 4, pp. 48–60, 2013.

[13] Y. M. Heong *et al.*, "The Level of Marzano Higher Order Thinking Skills among Technical Education Students," vol. 1, no. 2, 2011.

[14] S. Narayanan, T. Nadu, M. Adithan, and T. Nadu, "To Hots (Higher Order Thinking Skills)," vol. 6, no. 1, pp. 1–10, 2015.

[15] B. Tanujaya," Mapping the HOTS of Senior High Scholl Students In Mathematics Intructional Using Multidimensional Scaling," in *The Third International Seminar on Quality and Afordable Education*, pp. 259-263, 2014.

[16] I. N. Ghadi, K. A. Bakar, N. H. Alwi, and O. Talib, "Measuring Critical Thinking Skills of Undergraduate Students in Universiti Putra Malaysia," vol. 3, no. 6, pp. 1458–1466, 2013.

[17] E. Surya and F. A. Putri, "Improving Mathematical Problem-Solving Ability And Self-Confidence Of High School Students Through Contextual Learning Model," vol. 8, no. 1, pp. 85–94, 2017.

[18] B. Tanujaya, "Development of an Instrument to Measure Higher Order Thinking Skills in Senior High School Mathematics Instruction," vol. 7, no. 21, pp. 144–148, 2016.

[19] L. A. Jackson, E. A. Witt, A. I. Games, H. E. Fitzgerald, and A. Von Eye, "Computers in Human Behavior Information technology use and creativity : Findings from the Children and Technology Project," vol. 28, no. 2, pp. 370-376, 2012.

[20] A. K. Kenedi, "Desain Instrument Higher Order Thingking Pada Mata Kuliah Dasar-Dasar Matematika Di Jurusan PGSD," vol. 2, no. 1, pp.67-80, 2018.

[21] R.H Kuncorowati *et al*, "Mathematics creative thinking levels based on interpersonal intelligence Mathematics creative thinking levels based on interpersonal intelligence," 2017.

[22] S. Ahmad *et al*," The instruments of higher order thinking skills,", 2018.

[23] L. A. Raub, N. A. Shukor, M. Y. Arshad, and M. S. Rosli, "An Integrated Model to Implement Contextual Learning with Virtual Learning An Integrated Model to Implement Contextual Learning with Virtual Learning Environment for Promoting Higher Order Thinking Skills in Malaysian Secondary Schools," no. June, pp. 40–46, 2015.

[24] R. M. Magsino, "Enhancing Higher Order Thinking Skills in a Marine Biology Class through Problem-Based Learning," vol. 2, no. 5, pp. 1–6, 2014.

[25] A. Kiswanto, "The Effect of Learning Methods ad the Ability of Students Think Logically to the Learning Outcomes on natural Sciences of Grade IV's Student," *Adv. Soc. Sci. Educ. Humanit. Res.*, vol. 118, pp. 1040–1046, 2017.

[26] K. H Tseng, *et al*, "Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment," vol. 23, no. 1, pp. 87-102.2013.

[27] R. Ahmad and S. Bayat, "Collaborative Problem-Based Learning In Mathematics : A Cognitive Load Perspective," vol. 32, no. 2011, pp. 344–350, 2012.

[28] A. H. Abdullah, N. Liyana, Z. Abidin, and M. Ali, "Analysis of Students ' Errors in Solving Higher Order Thinking Skills (HOTS) Analysis of Students ' Errors in Solving Higher Order Thinking Skills (HOTS) Problems for the Topic of Fraction," vol. 11, no. 21, pp. 133-142, 2015.

[29] H.G Seyhan, "The Investigation of the Perception of Problem Solving Skills by Pre-Service Science Teachers in the Science Laboratory," vol. 6, no. 2, pp. 142-161, 2014.

[30] I.C Culaste, "Cognitive skills of mathematical problem solving of grade 6 children," vol. 1, no. 1, pp. 120-125, 2011.

[31] F.M Singer and C. Voica, Is Problem Posing a Tool for Identifying and Developing Mathematical Creativity. Springer: New York,2015.

[32] E. E. Arıkan, "Investigation of Problem-Solving and Problem-Posing Abilities of Seventh-Grade Students *," vol. 15, no. 5, pp. 1403–1416, 2015.

[33] R. Rosli, M. M. Capraro, and R. M. Capraro, "The Effects of Problem Posing on Student Mathematical Learning : A Meta-Analysis," vol. 7, no. 13, pp.227-241, 2014.

[34] O.D.P Herawati, R.A Siroj and M.D Basir," Pengaruh pembelajaran problem posing terhadap kemampuan pemahaman konsep matematika siswa kelas XI IPA SMA Negeri 6 Palembang vol. 4, no. 1, pp. 70-80, 2010.

[35] F. M. Firdaus and T. Herman, "Improving Primary Students ' Mathematical Literacy Through Problem Based Learning And Direct Instruction," vol. 12, no. 4, pp. 212–219, 2017.

[36] A. Purnamaningrum, S. Dwiastuti, and R. M. Probosari, "Peningkatan Kemampuan Berpikir Kreatif Melalui Problem Based Learning (Pbl) Pada Pembelajaran Biologi Siswa Kelas X-10 SMA Negeri 3 Surakarta," vol. 4, no. 3, pp. 39–51, 2012.

[37] T. Papinczak, T. Tunny, and L. Young, "student-teacher interactions Conducting the symphony : a qualitative study

of facilitation in problem-based learning tutorials," vol. 43, no.4, pp. 377–383, 2009.

[38] R. Rosnawati," Implementation of Problem-Based Learning in terms of Student Mathematical Creative Thinking," vol. 1097, no.1, p. 012111, 2009.

[39] D. S. Memnun, "Ondokuz Mayıs Üniversitesi Eğitim Fakültesi Dergisi Ortaokul Öğrencilerinin Matematik Problemi Çözmeye İlişkin İnançlarının İncelenmesi," vol. 34, no.1, pp. 75-98, 2015.

[40] I. Bilgin and Ş. Erdal, "The Effects of Problem-Based Learning Instruction on University Students ' Performance of Conceptual and Quantitative Problems in Gas Concepts," vol. 5, no. 2, pp. 153–164, 2009.

[41] D. K. Apple and W. Ellis, "Learning How to Learn : Improving the Performance of Learning," vol. 7, no. 1, pp. 21–28, 2015.

[42] S. Sunyono and A. Meristin, "The Effect Of Multiple Representation-Based Learning (Mrl) To Increase Students ' Understanding Of Chemical Bonding Concepts," vol. 7, no. 4, pp. 399–406, 2018.