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The Effect of Problem Based Learning and Open-Ended Learning on Mathematics Creative Thinking Ability: A Meta Analysis Study

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Abstract: This study aims to analyze the effect of Problem Based Learning (PBL) and Open Ended Learning (OEL) on the ability to think creative mathematically based on the effect size category, education level, and learning materials. This research method is a meta-analysis by reviewing several journals that have been published online. This study used 15 journals on PBL and 15 journals on OEL related to mathematical creative thinking skills. The instrument in this meta-analysis was carried out with a coding category sheet according to the research variables, namely: the year of the study, the title of the study, the level of education, the material used in the study, also the independent variable and dependent variable of study. The data analysis technique used is descriptive statistics. The results of the meta-analysis showed that PBL had a higher effect than OEL on students' mathematical creative thinking abilities. Based on the level of education, PBL has more influence on junior high school students, while OEL has more influence on students at high school level. In terms of learning materials, PBL has more influence on SPLDV material than other materials, while OEL has more influence on social arithmetic material.

Keywords: mathematical creative thinking ability, meta analysis, *Open-Ended Learning*, *Problem Based Learning*.

Abstrak: *Penelitian ini bertujuan untuk menganalisis pengaruh Problem Based Learning (PBL) dan Open Ended Learning (OEL) terhadap kemampuan berpikir kreatif matematis berdasarkan kategori effect size, jenjang pendidikan, dan materi pembelajaran. Metode penelitian ini adalah meta analisis dengan mengkaji beberapa jurnal yang sudah terpublikasi secara online. Penelitian ini menggunakan 15 jurnal tentang PBL dan 15 jurnal tentang OEL terkait kemampuan berpikir kreatif matematis. Instrumen penelitian berupa lembar pemberian kode (coding category) sesuai variabel penelitian yaitu: tahun penelitian, judul penelitian, jenjang pendidikan, materi yang digunakan dalam penelitian, serta variabel bebas dan variabel terikat penelitian. Teknik analisis data yang digunakan adalah statistik deskriptif. Hasil penelitian meta analisis menunjukkan bahwa PBL memberikan pengaruh yang lebih tinggi dibandingkan OEL terhadap kemampuan berpikir kreatif matematis siswa. Berdasarkan jenjang pendidikan, PBL lebih berpengaruh pada siswa jenjang SMP, sedangkan OEL lebih berpengaruh pada siswa jenjang SMA. Dari segi materi pembelajaran, PBL lebih berpengaruh pada materi SPLDV dibandingkan materi lainnya, sedangkan OEL lebih berpengaruh pada materi aritmetika sosial.*

Kata kunci: *kemampuan berpikir kreatif matematis, meta analisis, Open-Ended Learning, Problem Based Learning.*

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▪ INTRODUCTION

The ability to think creatively is a cognitive aspect that needs to be possessed as a provision for facing competition and also challenges in the current era of globalization. When faced with a problem, a creative person will be able to determine various alternative solutions to solve the problem. In accordance with the opinion of Munarsih, et al. (2019) that creative individuals will easily find new information and relate it to the information they already have, then process it to develop new ideas and choose the right solution strategy to solve the problem at hand. Therefore, it is important for students to have the ability to think creatively, especially in learning mathematics because students will often be faced with problems that cannot be solved in the same way as before.

The results of an international survey conducted by PISA (Program for International Assessment) in 2018 showed that Indonesia was ranked 73 out of 79 countries in mathematical literacy skills with an acquisition score of 379 out of an ideal score of 500 (La Hewi & Shaleh, 2020). Even though PISA questions do not only test students' simple math skills, but level 4-6, which is the level where students are tested for their high-level thinking skills (Setiawan et al., 2014). Furthermore, Soeyono (2014), Pane, et al. (2018) revealed that higher-order thinking skills are skills to connect, manipulate and change the knowledge and experience that is owned to think critically and creatively in an effort to make decisions when solving problems. Thus, students' mathematical creative thinking skills in Indonesia still need to be improved.

The ability to think creatively cannot appear by itself, the teacher must be able to train with learning that raises problems with the procedure for solving it requires planning, not just using formulas and theories. The learning atmosphere that encourages the development of creative thinking skills is learning that gives students the freedom to express their opinions in learning activities and solve mathematical problems in ways they find themselves (Suastika, 2017; La Moma, 2015). In addition, Ayele (2016) stated that creativity in mathematics is enhanced by implementing teaching using the right technology, open activities and non-routine problems accompanied by several correct answers, group discussions, cooperation, collaboration and social support.

Problem Based Learning (PBL) is a learning model that presents authentic, interesting and real-life problems to students, then resolved collaboratively by utilizing various sources of knowledge (Rusman, 2014). Students have greater responsibility for the learning process, because students work more than just listening to information. The role of the teacher in this case is to develop students' awareness of what to do (independently) in learning mathematics, try to involve students to be directly involved in the learning process, construct their own knowledge, experience for themselves, discover for themselves and not just memorize. Approved by Unal (2019), Padmavathy & Mareesh (2013) that PBL provides a platform for students to think, be active, exchange ideas through class discussions or group study, and provide motivation.

Apart from PBL, there are still lessons that also focus on problem solving. Open Ended Learning (OEL) is learning that provides an open problem, namely problems that can be solved by solving more than one strategy or more than one correct answer then the results will be discussion between groups. Students are asked to develop methods, different ways of obtaining solutions, where the teacher remains the facilitator and guides students. Through this open-ended problem students can improve their mathematical thinking skills which are more meaningful and varied, can encourage students to think more openly and be able to work together, are competent in solving problems, and communicate logically and argumentatively (Pariasa et al., 2015). The

variety of methods or procedures for solving problems can be used by teachers to provide experience to students in finding something new based on previously acquired mathematical knowledge, skills, and thinking (Nasution, 2013).

Based on this description, this study aims to analyze the effect of PBL and OEL learning on creative thinking skills based on the category effect size, education level, and learning material. Like most similar studies, this meta-analysis is expected to be useful in the field of education, especially mathematics teachers in implementing learning that is in accordance with the ability to think creatively based on the category effect size, education level, and learning material appropriately.

▪ METHOD

The method used in this research is meta-analysis by reviewing several journal that have been published online. Meta analysis is a statistical technique to combine the results of 2 or more similar studies so that a quantitative data guide is obtained (Anwar, 2015). This study used 15 journals on PBL and 15 journals on OEL related to mathematical creative thinking skills. Furthermore, journals are grouped based on coding to make data collection and analysis easier. Therefore, the instrument in this meta-analysis was carried out with a coding category sheet according to the research variables, namely: the year of the study, the title of the study, the level of education, the material used in the study, also the independent and dependent variable of study.

The data analysis technique used is descriptive statistics. The data tabulation steps include: (1) identification of the appropriate variables, (2) identification of the mean and standard deviation of the experimental and control group data for each subject / sub-study, (3) calculating the effect size based on mean and standard deviation using the Cohen formula (Thalheimer & Samantha, 2002), (4) determining the effect of the learning models based on the effect size criteria which are classified into small effects, moderate effects, and large effects.

▪ RESULT AND DISCUSSION

The results of journal search based on observational data coding can be seen in Table 1. Grouping This data is useful for making it easier for researchers to analyze the results of the data for each grouping effect size.

Table 1. Results of search journals based on observation data encoding

Specification	Effect Size Category		Level of Education		Learning Materials	
	PBL	OEL	PBL	OEL	PBL	OEL
Large Effect	14	13				
Moderate Effect	1	2				
Small Effect	-	-				
Elementary School (ES)			6	6		
Junior High School (JHS)			5	5		
Senior High School (SHS)			4	4		
Two-dimentional Figure					2	2
Geometry					2	2
Social Arithmetic					3	2
SPLDV					3	4
Opportunity					3	3
Algebra					2	2
Total	15	15	15	15	15	15

Based on A study of 15 journals on PBL and 15 journals on OEL on creative thinking skills obtained an effect size which was then grouped into large and medium effects categories. The results of the calculation and grouping are presented in Table 2 and Table 3.

Table 2. Results grouping based on effect size PBL

No.	Journal Code	Level of Education	Learning Materials	Effect Size (d)	Category
1	A1	SHS	*SPLDV*	5.22	Large Effect
2	A10	ES	Two-dimentional Figure	5.14	Large Effect
3	A13	JHS	Social Arithmetic	4.12	Large Effect
4	A6	SHS	Algebra	4.06	Large Effect
5	A7	JHS	*SPLDV*	3.86	Large Effect
6	A12	SHS	Opportunity	3.66	Large Effect
7	A4	SHS	Opportunity	3.00	Large Effect
8	A14	JHS	Social Arithmetic	2.87	Large Effect
9	A2	SHS	Opportunity	2.84	Large Effect
10	A3	JHS	Social Arithmetic	2.59	Large Effect
11	A11	JHS	*SPLDV*	2.35	Large Effect
12	A9	ES	Geometry	1.90	Large Effect
13	A15	SHS	Algebra	1.71	Large Effect
14	A8	ES	Geometry	1.16	Large Effect
15	A5	ES	Two-dimentional Figure	0.86	Moderate Effect
Average Effect Size Overall ($\bar{d}$)				3.02	Large Effect

The results of the analysis in Table 2 show that the overall average effect size PBL of the fifteen experimental studies was 3.02 which was included in the large effect category. The average effect size overall confirms the results that PBL has a great influence on the ability to think creatively in mathematics.

Tabel 3. Results grouping based on effect size OEL

No.	Journal Code	Level of Education	Learning Materials	Effect Size (d)	Category
1	A22	SHS	Opportunity	5.51	Large Effect
2	A23	SHS	Algebra	5.42	Large Effect
3	A30	JHS	Social Arithmetic	4.99	Large Effect
4	A25	JHS	Social Arithmetic	4.71	Large Effect
5	A24	JHS	*SPLDV*	4.23	Large Effect
6	A18	JHS	*SPLDV*	3.12	Large Effect
7	A17	JHS	*SPLDV*	2.89	Large Effect
8	A21	SHS	Algebra	2.66	Large Effect
9	A26	SHS	Opportunity	2.40	Large Effect
10	A28	ES	Geometry	2.34	Large Effect
11	A19	ES	Two-dimentional Figure	1.85	Large Effect
12	A27	ES	Two-dimentional Figure	1.76	Large Effect
13	A16	JHS	*SPLDV*	1.31	Large Effect
14	A20	ES	Geometry	0.87	Moderate Effect
15	A29	SHS	Opportunity	0.42	Moderate Effect
Average Effect Size Overall ($\bar{\mathbf{d}}$)				2.97	Large Effect

The results of table 3 analysis show that the overall average effect size OEL for fifteen experimental studies is 2.97 which is included in the large effect category. The average effect size overall confirms the result that OEL has a great influence on the ability to think creatively in mathematics.

Based on the results from Table 2 and Table 3, both PBL and OEL have an influence on the ability to think creatively in mathematics. However, when compared with the average effect size PBL, OEL has average effect size a lower. This shows that PBL has more influence on mathematical creative thinking skills than OEL.

Several previous studies have strengthened the results of this study, that PBL affects students' mathematical creative thinking abilities (Maskur et al., 2020; Sariningsih & Kadarisma, 2016; Choridah, 2013; Schettino, 2016). According to Hutauruk, et al. (2020), Khoiri, et al. (2013), and Silviani, et al. (2018) the PBL model is carried out by exposing students to real problems in everyday life so that it makes it easier for students to understand and seek various kinds of solutions, which encourages students to play a more active role and think creatively. Through authentic problems or problems related to real life, students can develop their own knowledge and dig information independently to solve problems based on their experiences (Putri & Hasbi, 2018; Hung, 2016; Botty et al., 2016). This is in accordance with constructivism learning theory which views cognitive development as a process in which children actively build a system of meaning and understanding reality through their experiences and interactions (Abdurrozak et al., 2016).

Furthermore, the journals on PBL and OEL that have been analyzed were each tested against a different level of education. The results of grouping effect sizes based on education levels are presented in Table 4.

Tabel 4. Results of grouping effect size based on education level

Level of Education	PBL		OEL	
	$\bar{d}$	Category	$\bar{d}$	Category
Elementary School	2.27	Large Effect	1.71	Large Effect
Junior High School	3.51	Large Effect	2.89	Large Effect
Senior High School	3.39	Large Effect	4.00	Large Effect

The results of the analysis in Table 4, namely PBL has a significant effect. high towards students at the junior high school level with an average effect size of 3.51. According to Piaget's theory of cognitive development, junior high school students between 12-15 years are at the formal operation stage, where they develop new tools to manipulate information, can think abstractly, deductively, and inductively, can consider answers, handle problems flexibly, test hypotheses, and draw conclusions. Through PBL, students are faced with real-life scenarios or problems that need to be analyzed, then apply deductive and inductive processes to understand problems and find solutions (Amalia et al., 2017). This is one of the reasons why the influence of PBL on the creative thinking skills of students at the junior high school level is higher than that of students at the high school and elementary school levels.

The results of the analysis on the application of OEL have a high effect on high school students with an average effect size of 4.00. In accordance with Piaget's cognitive development theory that high school students aged 15-18 years, are still continuing from the formal operation stage of junior high school students, it's just that they are more developing their intellectual skills, such as increased problem-solving

analytical power, more creative thinking and problem solving. At this stage, students must be given more opportunities to explore various possible alternative solutions in solving open-ended problems according to their level of thinking. Through OEL, students have the opportunity to gain more knowledge, experience discovery, recognize and solve problems because this approach manages problems with different methods and more than one solution (Ritonga et al., 2018; Shimada & Becker, 1997). Therefore, OEL has a lot of compatibility with the math components of high school students' thinking. In accordance with the results of research by Fatah, et al. (2016) that learning through OEL can further improve mathematical creative thinking skills in high school students even though the school category is different.

The journals analyzed also use several different learning materials. The results of grouping effect sizes based on learning materials are presented in Table 5.

Tabel 5. Results of grouping effect size based on learning materials

Learning Materials	PBL		OEL	
	$\bar{d}$	Category	$\bar{d}$	Category
Social Arithmetic	3.19	Large Effect	4.85	Large Effect
SPLDV	3.81	Large Effect	2.10	Large Effect
Opportunity	3.17	Large Effect	3.96	Large Effect
Algebra	2.88	Large Effect	4.04	Large Effect
Two-dimentional Figure	3.00	Large Effect	1.81	Large Effect
Geometry	1.53	Large Effect	1.61	Large Effect

The results of the analysis in Table 5 show that PBL has an effect the highest on the SPLDV material, but the lowest effect on the building material. This is shown from the results of the analysis effect size on the SPLDV material of 3.81. The order of the size of the effect size PBL based on the learning material from largest to smallest consecutively, namely SPLDV, social arithmetic, opportunities, flat shapes, algebra, and space shapes. In accordance with the research results of Rahma (2018) that PBL is suitable to be applied to SPLDV material because the problems given are more related to daily life so that it can make it easier for students to understand these problems.

It is different with OEL, its application has the highest influence on social arithmetic material. This is shown from the results of the analysis effect size on social arithmetic material of 4.85. The order of magnitude of the effect size OEL based on the learning material from largest to smallest, respectively, is social arithmetic, algebra, probability, SPLDV, flat shapes, and space shapes. OEL learning can improve mathematical creative thinking skills in social arithmetic material because students are more directed to the problem-solving process in order to develop higher-order thinking skills, students are not only required to get answers but also the process of how students arrive at these answers (Wahyuningsih et al., 2019).

▪ CONCLUSION

Based on the results of the analysis that has been done, the PBL and OEL learning models both have an influence on students' mathematical creative thinking abilities with a large effect category. However, PBL has a higher effect than OEL on students' mathematical creative thinking abilities. Based on the level of education, PBL has a positive effect at the junior high school level, while OEL has a more positive effect on the high school level. In terms of learning materials, PBL has more influence on

SPLDV material, while OEL has more influence on social arithmetic material. The author suggests further research that examines other variations of learning models related to mathematical creative thinking skills in other appropriate materials and other aspects of mathematical thinking skills.

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