Impact of OER-assisted Problem-based Learning on Creative Thinking and Self-Efficacy in Physics Education

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ABSTRACT: In the era of unlimited information, one method of learning is through the use of open education resources (OER) whereby It can be included into learning that is problem-based learning (PBL) to optimize students' low creative thinking. This current study describes and investigates the impact of PBL with OER support on the acquisition and enhancement of secondary students' creative thinking in the physics lesson viewed by the difference of self-efficacy. This study applied quasi-experiment research with pretest-post-test control group design in which 60 students in a public secondary school in Bandar Lampung were involved as the participant. Creative thinking test using physics content and self-efficacy questionnaire were administrated to students to collect the data. A few of statistical tests, such as: two ways ANOVA, paired t test, and independent t test whereby the software of SPSS v.26 was used to promote in analysing the data. Results found that there was a significant positive effect of the implementation of OER-assisted PBL on the acquisition and the enhancement of students' creative thinking in physics lesson. Although the level of students' self-efficacy has a significant role on the acquisition and enhancement of students' creative thinking in physics learning but it is not depended on the learning model used either OER-assisted PBL or DI. Consequently, educational practitioners in the field of physics education, such as lecturer and teacher can implement PBL assisted by OER, such as e-book, e-module, web-based environment, etc., to optimize students' creative thinking abilities or skills in which they can enhance their creative thinking, so getting the high achievement in physics subject. They also have to consider students' self-efficacy level as one of the important factors in optimizing students' creative thinking in physics learning.

Keywords: creative thinking, direct instruction, problem-based learning, open educational resources, self-efficacy.

I. INTRODUCTION

The fourth industrial revolution emphasizes automatization and collaboration among cyber technologies which include some processes, such as manufacture and logistic [1, 2]. Some professions, like as programmers, data analysts, and artificial intelligence designers are expected to grow rapidly. It is estimated that 95 million new jobs will grow at the same time 85 million jobs will perish [3, 4]. Towards this situation, consequently, It's essential for developing creative thinking to navigate the ambiguity, perspective triangulation, and content understanding [5], [6]. Educational system is demanded to teach knowledge and enhance competitive skills in dealing with the global competition [7-9]. Additionally, educational goals must evolve from knowledge to skills contributing to work preparedness [10, 11]. Moreover, realizing the objectives of national education needs learning innovation, learning activity design, metacognition empowerment, discussion, development of student-centered learning in which all of those are directed to optimize problem-solving, decision-making, critical thinking, and creativity [12-14].

Creative thinking is a thinking process finding out new ideas, insights, approaches, methods, and perspectives to understand and solve something [15, 16]. In a literature, Hooshyar et al. [17] stated that problem-solving requires creative thinking. In Bloom's taxonomy, Wu et al. [18] defined creative thinking as the summit of the cognitive aspect from the process dimension. In addition, it, a combination between reasoning and commitment to realize a creative product, is seen as someone's ability to overcome a problem with reasoning [19]. Some empirical researches, nevertheless, discovered that most of students still have problems with creative thinking [20-24]. Particularly, an empirical research in the field of physics education revealed that of 200 secondary students in Lampung province, Indonesia, 37.50% of students had a low category of creative thinking, moreover, 31.25% of them had a moderate classification of creative thinking [25]. Additionally, Khoiri et al. [26] also proved that students' creative thinking in project-based learning has not been optimal. It can be expected that the reason for students who have low creative thinking is that teachers tend to implement learning environments which are not suitable to the optimization of creative thinking. Moreover, they tend to use an easy product assessment to measure than encouraging students' problem-solving.

One of the efforts that can be carried out in optimizing students' creative thinking in physics is the application of problem-based learning (PBL) during the course of physics learning. Some literatures declared that the implementation of PBL is a method that optimize students' low abilities to think creatively [27-36]. Selecting PBL as one of the substitute methods for improving students' creative thinking is due to the PBL design can create and improve students' capacity for creative thinking, so it can build student self as analyzing people who able to justify, verify, and analyze the reality and validation of the obtained data, consequently they can adjust in variety of scenarios and circumstances [37, 38]. According to Le [39], in a literature, argued that PBL properly enhances creative thinking in that students will solve complex problems by working in small groups to search and collect various information to find out solutions. Students' knowledge is constructed in PBL, especially in discussion process and information source use. In a literature, Thomson [40] stated that PBL implementation needs the information literacy supporting to run smoothly. Limited information source, however, makes the given problem will not be contextual and well-structured and discussion can't run effectively. Therefore, teachers and students can utilize Open Educational Resources (OER) in which a few of literatures stated that OER aims to enhance the access to get the learning materials, especially related to physics subject [41, 42].

Beside OER-assisted PBL hypothesized that it can optimize students' creative thinking in physics learning, self-efficacy is also among the possible causes that decide the achievement of creative thinking. Some literatures stated that self-efficacy is individual's belief to complete certain tasks while defending their aptitude or expertise [43, 45]. Referring to a literature, Suparman and Juandi [46] stated that self-efficacy is built using four primary sources, such as indirect persuasion, states of mind and emotions, active mastery experience, and oral persuasion. These primary sources have the essential role on the enhancement or the reduction of students' self-efficacy level. Moreover, particularly Talosa et al. [44] argued that students' self-efficacy level to overcome challenges when attempting to solve physics problems will decide their favorable or unfavorable depending on their skills. It means that the optimization of students' creative ideas in physics lesson is not only stimulated by OER-assisted PBL but also indirectly by the degree of students' self-efficacy. Because of this, this research learns the causal correlation between OER-assisted PBL and students' creative thinking skills in the perspective of students' self-efficacy level.

To date, many empirical researches in physics education have studied the implementation of PBL assisted by OER, such as mobile video education, PhET simulation, E-book, E-module, Web-based environment, and E-learning for students' physics achievement [47-54]. Additionally, a few of empirical researches in physics learning focused on the implementation of PBL regarding students' creative skills [55, 56]. Moreover, a few of other empirical researches have studied the use of OER-assisted PBL in physics education for students' critical thinking [57, 58]. From those relevant empirical studies, it can be stated that there is a minimum of study which exactly focuses on creative thinking, self-efficacy, and OER-assisted PBL in physics education. Therefore, this recent study seeks to describes and examines the impact of PBL with OER assistance on the acquisition and enhancement of secondary students' creative thinking in the physics lesson viewed by the difference of self-efficacy. This study provides a significant contribution related to the optimization of students' creative thinking by implementing OER-assisted PBL considering students' self-efficacy level. The subsequent research inquiries are directed to operate and complete the current study's objectives, such as: (1) How is the description of students' self-efficacy in physics lesson both OER-assisted PBL class and direct instruction class? (2) How is the description of the acquisition of creativity of students' skill in physics lesson using OER-assisted PBL and direct instruction? (3) Is there a notable difference on the acquisition of creative thinking between students who learn using OER-assisted PBL and students who learn using direct instruction? (4) How is the description of improvements to students' creative thinking in physics lesson using OER-assisted PBL and direct instruction? (5) Does the application of OER-assisted PBL have a significant impact on the acquisition of students' creative thinking in physics lesson? (6) Does the implementation of direct instruction have a significant effect on the acquisition of students' creative skill in physics lesson? (7) Is there a notable difference on the improvement of creative thinking between students who learn using OER-assisted PBL and students who learn using direct instruction? (8) Does the level of students' self-efficacy have a significant impact on the acquisition and enhancement of students' creative skill in physics lesson? (9) Is there any a significant interaction effect between learning environment (OER-assisted PBL & direct instruction) and the degree of self-efficacy on the acquisition and enhancement of students' creative thinking in physics lesson?

II. LITERATURE REVIEW

1. CREATIVE THINKING SKILL

Creative thinking skill refers to the processes to generate an innovative product obtained from a directed activity. In a literature, Fraser [59] stated that creative thinking is an individual's ability in analyzing the new information, and combining the unique idea to solve the problems. Additionally, some literatures defined it as a mental activity used by students to build the new idea, and moreover, it combines between logical thinking and divergent thinking [60-62]. Moreover, Huang et al. [63] mentioned that one of the best levels of thinking that students can achieve is creative thinking, started from recalling to basic thinking to critical thinking to creative thinking. To thinking creatively, students pass through some phases, such as synthesizing ideas, planning the implementation of ideas, and applying ideas, so generating the new product, and it called as creativity. Duval et al. [64] defined creativity as an activity generating something which is novel, beneficial, and understandable. Furthermore, some literatures characterized creative thinking to be four main components, such as fluency, flexibility, originality, and elaboration [65-67]. Particularly, Hansen and Bertel [66] defined fluency as an ability to originate many arguments, answers, & problem-solving, and provide a lot of ways or suggestions in conducting everything and thinking more than one solution. Meanwhile, flexibility is the capacity to come up with multiple concepts, queries, and solutions as well as the ability to view an issue from several angles and change the approaches in getting the solution of a problem. Moreover, originality refers to an ability to emerge new and unique ideas, think the ill-structured way to express the ideas, and create unusual combination, whereas elaboration refers to an ability to enrich, appear, and develop the ideas or products, and add the detail situation so it can be more than interesting. In this current study, these components are used as criteria to assess students' creativity of thought in physics lesson.

2. SELF-EFFICACY

Self-efficacy is the conviction that one can perform several duties with a defense of their aptitude or expertise [44, 68, 69]. In the context of physics lesson, it can be seen as the opinions of the students to thinking and reasoning physically in resolving physics problems with their physical skill. The degree to which students are motivated in solving physics problems determined the degree of self-efficacy to carry out it. Additionally, students' level of confidence in their ability to overcome challenges in solving physics tasks will decide considering his or her skills, either positive or negative behavior. Moreover, Bandura [70] stated that self-efficacy is created from four primary sources, such as verbal persuasion, indirect experience, mental and emotional conditions, as well as an active mastery experience. Particularly, it is explained that vicarious experience refers to a person's background in performing the same task so they could watch and assess how they compared to another accomplished person, whereas enactive mastery experience is defined as an individual's experience that would have an effect, either positive or negative on an individual's self-efficacy. On the other hand, oral persuasion has an essential role in the enhancement of individual's self-efficacy in which students' self-efficacy, teachers of physics could provide encouragement and positive reinforcement to boost students' belief in the mathematical learning process. while students' self-efficacy in understanding physics content can be weakened by punishment and negative feedback from physics teachers. Meanwhile, an individual's psychological and emotional states, such as anxiety, weariness, and mood, also contribute to the construction of their increased self-efficacy; in particular, the reinforcement of an individual's self-efficacy occurs when their psychological and positive emotional states are enhanced and their psychological and negative states are reduced. These main sources are involved to design and create the questionnaire of self-efficacy in which this instrument is adopted to measure students' self-efficacy in physics learning.

3. PROBLEM-BASED LEARNING AND DIRECT INSTRUCTION

In a literature, Savery [71] stated that PBL refers to learning approach centered on students facilitating them to do research, integrate between practice and theory, and use your knowledge and abilities in deciding the ideal resolution to a particular issue. A few literatures also defined PBL as a learning approach which starts a certain topic using the complex problem and enables that it has more than one solution in which all of these are directed to facilitate the enhancement of problem-solving, critical thinking, and creativity [72-74]. Moreover, PBL has some unique characters, such as: (1) as a facilitator, the teacher, (2) the application of a clear procedure to aid in learning, (3) the application of real-world issues to encourage, contextualize, and integrate the learning, (4) the small-group instruction, (5) evaluation of PBL implementation, and (6) reflective and self-regulated learning [71, 75]. Additionally, Yew and Goh [76] mentioned that the learning process using PBL has some phases, such as: (1) finding the problem, (2) analyzing the problem, (3) investigating and solving the problem, (4) reporting and discussing in small group, (5) representing the results of discussion, and (6) reflecting and evaluating. Particularly, this recent study adapts the phases of PBL proposed by Yew and Goh [76] to be implemented in experiment classroom.

On the other hand, direct instruction (DI) refers to learning model that can build students to learn and mastery basic skills and get the information gradually [77]. Moreover, Mubai et al. [78] stated that DI is a learning model using the demonstration and explanation of teacher combined to exercise and feedback of students to help them in obtaining real knowledge and skill needed to advanced learning. In a literature, McMullen and Madelaine [79] mentioned that there are some unique characters of DI, such as: (1) model effect on students including learning purpose and assessment, (2) syntax based on learning pattern and process, and (3) analysis system and learning environment are adjusted to promote the success of learning activities. Moreover, Eppley and Dudley-Marling [80] argued that DI has some phases in the learning process, such as: (1) presenting learning purpose and getting students ready, (2) demonstrating comprehension and skill, (3) directing the practice, (4) checking recognizing and providing feedback, and (5) providing the chance for advanced practice. In particular, this current study uses the phases of DI proposed by Eppley and Dudley-Marling [80] to be implemented in control classroom.

4. OPEN EDUCATIONAL RESOURCES AND PHYSICS LESSON

Open educational resources (OER) refer to beneficial open licensed document and media for teaching, learning, educating, assessing, and researching. OER consist of lecture, learning material, content module, learning object, journal, and various supported tools for presenting the learning content [81]. Moreover, Mishra [82] defined OER as learning material or research result which is exist in various open licensed media and free to be accessed, re-used or adapted, and re-deployed by users. Particularly, OER usually consist of textbook, curriculum, syllabus, note, video tutorial, and animation. In a literature, Pawlowski and Bick [83] mentioned that OER should follow the principle of 5R, such as: (1) retain-can be accessed to be downloaded, (2) reuse-can be re-used, (3) revise-can be changed to be revised or developed, (4) remix-can be modified, adapted, and used with other materials, and (5) redistribute-can be duplicated and spread. The 5R principle explains that the implementation of new license is included as the requirement of OER provision in which the usual license applied on OER is creative commons license (CC license). The application of CC license on OER can be found in some online platforms, such as Wikimedia, OER Commons, Encyclopedia of Life, Public Library of Science, School of Open, and Story Weaver[84-88]. Meanwhile, Sulisworo et al. [57] mentioned a few of OER forms in Indonesia, such as Wikipedia, UT-OER (SUAKA-UT), and USK-OER. Some forms of OER are used and applied in physics lesson in which students need other resources to learn physics topic in the learning environment of PBL. Specifically, a variety of OER forms used in this recent study are such as E-module and E-book in public library in some colleges or universities.

III. MATERIAL AND METHOD

1. RESEARCH DESIGN AND APPROACH

To fulfill the goal of this recent study, quantitative approach was used in which in a literature, Creswell and Creswell [89] stated that this approach can facilitate in providing the description and examining hypothetical questions by a series of inferential statistics test. Moreover, quasi-experiment was research type used in this study. The limitation in conducting random assignment in the educational field, especially in physics education was the reason that this research type was selected [46, 90-95]. Additionally, this study used some research designs, such as posttest only control group design without randomization, one group pretest-posttest design, and pretest-posttest control group design without randomization [96]. Particularly, one group pretest-posttest design was used to describe and analyze the effect of OER-assisted PBL and DI on the acquisition of students' creative thinking in physics lesson. Conversely, though design of the posttest only control group without randomization was used to describe and analyze the difference of effect of OER-assisted PBL and DI on the acquisition of students' creative thinking in physics lesson. Meanwhile, design of the pretest-posttest control group without randomization was used to analyze the difference of effect of OER-assisted PBL and DI on the improvement of students creative thinking in physics lesson.

2. PARTICIPANT

This study involved 60 tenth-grade students in a public secondary school in Lampung Province, Indonesia. They were selected by using simple random sampling in that there were six classrooms in tenth-grade in the school and early physics competence of students was equal [97]. Specifically, the participants were grouped to be two classrooms in which one classroom be an experiment class (16 males and 14 females) and another one classroom be a control class (15 males and 15 females). Additionally, experiment classroom was intervened by OER-assisted PBL while control classroom was intervened by DI.

3. INSTRUMENT

This study used a few of instruments, such as creative thinking test and self-efficacy questionnaire. Creative thinking test was designed and contained four essay physics problems whereby each physics problem represented each of creative thinking indicators, such as flexibility, fluency, originality, and elaboration proposed by Hansen and Bertel [66]. Each of physics problem 0 was the minimum score and 25 was the maximum score. Newton laws about movement was used as physics content to measure students' creative thinking in physics lesson. This test had been validated theoretically by one lecturer and one teacher in physics education, and also validated empirically in which all of test items was valid and reliable (α = 0.87). Kennedy [98] stated that the Cronbach Alpha score was categorized as high reliability. Furthermore, self-efficacy questionnaire used to measure students' self-efficacy level in physics lesson was adopted from Arafah et al. [99]. This questionnaire consisted of 25 negative-directed statements and 25 positive-directed statement with 5-point Likert scale (positive direction: 1 = not true at all, 2 = hardly true, 3 = somewhat true, 4 = largely true, 5 = exactly true, and negative direction: 1 = exactly true, 2 = largely true, 3 = somewhat true, 4 = hardly true, 5 = not true at all). This questionnaire had been valid and reliable (α = 0.79), and ready to be used to measure students' self-efficacy level, especially in physics lesson.

4. PROCEDURE

To conduct this study, there were some steps that we passed through. Firstly, we observed the actual problem in physics learning in which it was low creative thinking, and we tried to provide solution for this problem by implementing OER-assisted PBL in physics classroom and also considered the level of students' self-efficacy. Secondly, we designed creative thinking test so it could be a valid and reliable instrument, and adopted the valid and reliable self-efficacy questionnaire. Thirdly, we administered a few of letters to get the permission from educational authority to do an experiment in the public secondary school. Thirdly, we organized the research participants to be two groups, such as experiment classroom and control classroom. Fourthly, we measured the level of students' self-efficacy using self-efficacy questionnaire. Fifthly, we carried out the pretest to students about creative thinking test for 90 minutes. Sixthly, we implemented OER-assisted PBL in experiment class and DI in control class during two months (8 meetings) for each classroom. Seventhly, we carried out the posttest to students regarding creative thinking test for 90 minutes. Eighthly, we analyzed the data and interpreted it.

5. ANALYSIS TECHNIQUE

To classify students' self-efficacy level, the categorization of variable proposed by Suparman et al. [100] was applied in which the score of students' self-efficacy was classified as $x \leq 116.67$ (low), $116.67 < x \leq 183.33$ (moderate), and $x > 183.33$ (high). Descriptive statistics, such as mean, deviation standard, minimum, maximum, and sample size were used to describe the acquisition of students' creative thinking in physics lesson. Additionally, N-gain score was used to describe the enhancement of students' creative thinking in physics lesson whereby a few literatures classified N-gain value as $g < 0.30$ (low), $0.30 \leq g < 0.70$ (moderate), and $g > 0.70$ (high) [101, 102]. Moreover, paired sample t test was used to examine the effect of OER-assisted PBL or DI on the acquisition of students' creative thinking in physics lesson, whereas independent sample t test was used to examine the difference of the effect of OER-assisted PBL and DI on the acquisition and the enhancement of students' creative thinking in physics lesson [97]. Meanwhile, two ways ANOVA was used to examine the effect of students' self-efficacy level on the acquisition and the improvement of students' creative thinking and examine the interplay between the learning model (OER-assisted PBL & DI) and self-efficacy level on the acquisition and the improvement of students' creative thinking in physics lesson [103]. All calculations of descriptive and inferential statistics used Ms. Excel 2021 and SPSS v.26.

IV. DATA ANALYSIS

1. THE DESCRIPTION OF THE ACQUISITION OF STUDENTS' SELF-EFFICACY

To answer the first research question (RQ1), analysis results of descriptive statistics on the acquisition of students' self-efficacy are shown in Table 1.

Table 1. The acquisition of students' self-efficacy in physics lesson

Statistics	OER-assisted PBL	DI
Mean	153.71	149.83
Deviation Standard	11.27	9.38
Sample Size	30	30

From Table 1, it can be stated that overall, students in both OER-assisted PBL classroom and DI classroom had moderate self-efficacy. Moreover, students' self-efficacy in OER-assisted PBL classroom was higher than students' self-efficacy in DI classroom. Additionally, the distribution of students' self-efficacy level in each of classroom is presented in Figure 1.

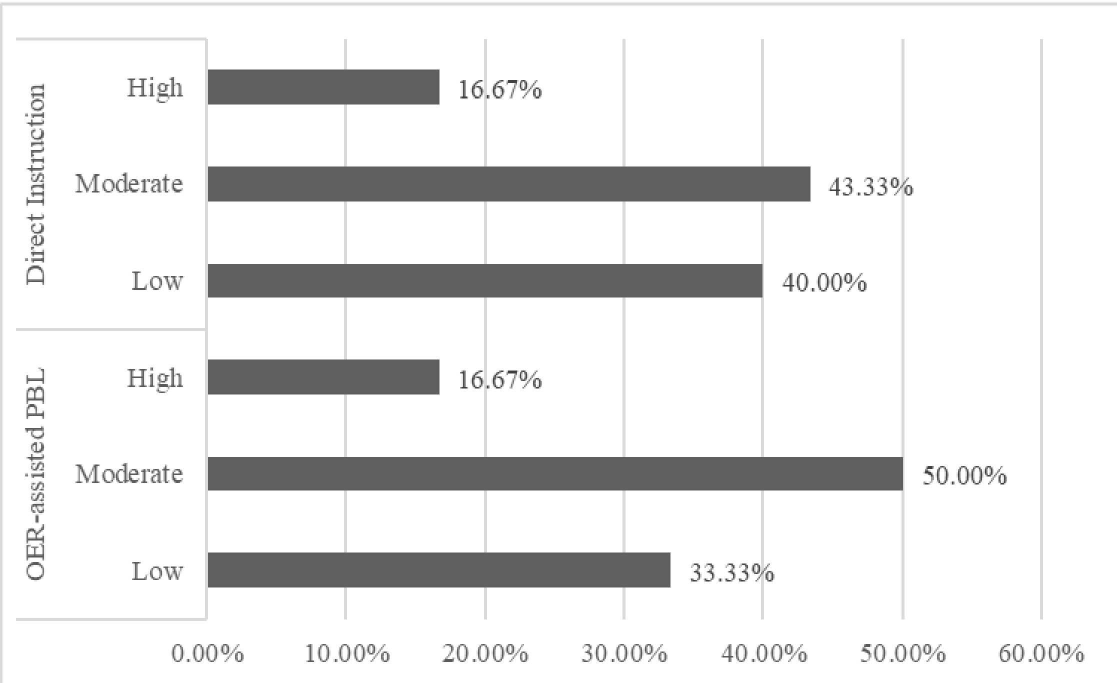

FIGURE 1. The distribution of students' self-efficacy level in the classroom of OER-assisted PBL and DI

From Figure 1, it can be stated that there were ten students who had low self-efficacy in the classroom of OER-assisted PBL, followed by 15 students who had moderate self-efficacy and five students who had high self-efficacy. Meanwhile, there were twelve students who had low self-efficacy in DI classroom, followed by 13 students who had moderate self-efficacy and five students who had high self-efficacy. This shows that most of students in the classroom of OER-assisted PBL and DI tend to have low and moderate self-efficacy in physics lesson.

2. THE DESCRIPTION OF THE ACQUISITION OF STUDENTS' CREATIVE THINKING

To answer the second research question (RQ2), analysis results of descriptive statistics on the acquisition of students' creative thinking are shown in Table 2.

Table 2. The acquisition of students' creative thinking in physics lesson

Statistics	OER-assisted PBL		Direct Instruction	
	Pretest	Posttest	Pretest	Posttest
Mean	30.73	75.53	40.43	60.17
Deviation Standard	6.068	6.004	6.033	6.330
Minimum	21	66	31	50
Maximum	40	85	50	70
Sample Size	30	30	30	30

From Table 2, it can be stated that before intervened by OER-assisted PBL and DI, students' creative thinking in OER-assisted PBL classroom was lower than students' creative thinking in DI classroom. Meanwhile, after given by the learning environments, such as OER-assisted PBL and DI, students' creative thinking in OER-assisted PBL classroom was higher than students' creative thinking in DI classroom. This indicates that descriptively there is a positive effect of the implementation of OER-assisted PBL on the acquisition of students' creative thinking in physics lesson.

3. THE DIFFERENCE OF THE ACQUISITION OF STUDENTS' CREATIVE THINKING

To answer the third research question (RQ3), analysis results of independent sample t test are shown in Table 3.

Table 3. The results of independent sample t-Test

	Homogeneous Assumption	t-value	Degree of Freedom	Sig. (2-tailed)
Creative Thinking	Equal variances assumed	9.647	58	0.000
	Equal variances not assumed	9.647	57.838	0.000

Table 3 shows that significant value of independent sample t test was less than 0.05 in which this interprets that there is a significant different of the acquisition of creative thinking in physics lesson between students who study using OER-assisted PBL and students who study using DI. Moreover, this means that to optimize students' creative thinking in physics lesson, the use of OER-assisted PBL is more effective than the use of DI.

4. THE DESCRIPTION OF THE ENHANCEMENT OF STUDENTS' CREATIVE THINKING

To answer the fourth research question (RQ4), analysis results of descriptive statistics on the N-Gain value of students' creative thinking are shown in Table 4.

Table 4. The enhancement of students' creative thinking in physics lesson

Statistics	OER-assisted PBL	Direct Instruction
Mean	0.648	0.333
Deviation Standard	0.068	0.065
Minimum	0.53	0.18
Maximum	0.76	0.45
Sample Size	30	30

From Table 4, it can be stated that students in both OER-assisted PBL classroom and DI classroom have moderate enhancement of creative thinking. Descriptively, however, the enhancement of students' creative thinking in OER-assisted PBL classroom was higher than the enhancement of students' creative thinking in DI classroom. This indicates that there is a positive effect of the implementation of OER-assisted PBL on the enhancement of students' creative thinking in physics lesson.

5. THE EFFECT OF OER-ASSISTED PBL AND DI ON THE ACQUISITION OF CREATIVE THINKING

To answer the fifth and sixth research question (RQ5 & RQ6), analysis results of paired dependent sample t test are shown in Table 5.

Table 5. The results of paired dependent sample t-Test

		t-value	Df	Sig. (2-tailed)
Pair 1	Posttest Experiment-Pretest Experiment	54.737	29	0.000
Pair 2	Posttest Control-Pretest Control	28.338	29	0.000

From Table 5, it can be stated that significant values of paired dependent sample t test for OER-assisted PBL class and DI class was less than 0.05 whereby this interprets that the implementation of OER-assisted PBL or DI has a significant effect on the acquisition of students' creative thinking in physics lesson. This shows that the implementation of OER-assisted PBL or DI is effective in enhancing students' creative thinking in physics lesson.

6. THE DIFFERENCE OF THE ENHANCEMENT OF STUDENTS' CREATIVE THINKING

To answer the seventh research question (RQ7), analysis results of independent sample t test on the N-Gain value are shown in Table 6.

Table 6. The Results of Independent Sample t Test on the N-Gain Value

	Homogeneous Assumption	t-value	Degree of Freedom	Sig. (2-tailed)
Creative Thinking	Equal variances assumed	18.171	58	0.000
	Equal variances not assumed	18.171	57.838	0.000

Table 6 shows that significant value of independent sample t test on the N-Gain value was less than 0.05 in which this interprets that there is a significant different of the enhancement of creative thinking in physics lesson between students who study using OER-assisted PBL and students who study using DI. Moreover, this means that to optimize students' creative thinking in physics lesson, the use of OER-assisted PBL is more effective than the use of DI.

7. THE EFFECT OF STUDENTS' SELF-EFFICACY ON THE ACQUISITION AND ENHANCEMENT OF STUDENTS' CREATIVE THINKING

To answer the eighth research question (RQ8), analysis results of two ways ANOVA on the acquisition and the enhancement of students' creative thinking are shown in Table 7 and Table 8.

Table 7. The results of two ways ANOVA on the acquisition of students' creative thinking

Source	F-value	Sig. value	Partial Eta Squared
Corrected Model	28.317	0.000	0.724
Intercept	7,425.491	0.000	0.993
Learning Model	89.883	0.000	0.625
Self-Efficacy	7.959	0.001	0.228
Learning Model * Self-Efficacy	2.915	0.063	0.097

From Table 7, it can be stated that the value of partial eta squared for the variable of self-efficacy was 0.228 in which Cohen et al. (2018) classified it as modest effect. This means that indirectly, the level of students' self-efficacy has modest effect on the acquisition of students' creative thinking in physics lesson. Moreover, the significant value of F test for the variable of self-efficacy was less than 0.05 whereby this interprets that the level of students' self-efficacy has a significant effect on the acquisition of students' creative thinking skills in physics lesson.

Table 8. The results of two ways ANOVA on the enhancement of students' creative thinking

Source	F-value	Sig. value	Partial Eta Squared
Corrected Model	98.839	0.000	0.901
Intercept	3,638.195	0.000	0.985
Learning Model	356.967	0.000	0.869
Self-Efficacy	12.866	0.000	0.323
Learning Model * Self-Efficacy	1.372	0.262	0.048

From Table 8, it can be stated that the value of partial eta squared for the variable of self-efficacy was 0.323 in which Cohen et al. [97] classified it as modest effect. This means that indirectly, the level of students' self-efficacy has modest effect on the enhancement of students' creative thinking in physics lesson. Moreover, the significant value of F test for the variable of self-efficacy was less than 0.05 whereby this interprets that the level of students' self-efficacy has a significant effect on the enhancement of students' creative thinking skills in physics lesson.

8. THE INTERACTION EFFECT BETWEEN LEARNING MODEL AND SELF-EFFICACY ON THE ACQUISITION AND ENHANCEMENT OF STUDENTS' CREATIVE THINKING

To answer the ninth research question (RQ9), analysis results of two ways ANOVA on the acquisition and the enhancement of students' creative thinking are shown in Table 7 and Table 8. From Table 7, it can be stated that the value of partial eta squared for the variable of learning model * self-efficacy was 0.097 in which Cohen et al. [97] classified it as weak effect. This means that indirectly, the interaction between learning model (OER-assisted PBBL and DI) and the level of self-efficacy has weak interaction effect on the acquisition of students' creative thinking in physics lesson. Moreover, the significant value of F test for the variable of learning model * self-efficacy was more than 0.05 whereby this interprets that there is no significant interaction effect between learning model (OER-assisted PBBL and DI) and the level of self-efficacy on the acquisition of students' creative thinking skills in physics lesson.

Furthermore, from Table 8, it can be stated that the value of partial eta squared for the variable of learning model * self-efficacy was 0.048 in which Cohen et al. [97] classified it as weak effect. This means that indirectly, the interaction between learning model (OER-assisted PBBL and DI) and the level of self-efficacy has weak interaction effect on the enhancement of students' creative thinking in physics lesson. Moreover, the significant value of F test for the variable of learning model * self-efficacy was more than 0.05 whereby this interprets that there is no significant interaction effect between learning model (OER-assisted PBBL and DI) and the level of self-efficacy on the enhancement of students' creative thinking skills in physics lesson.

V. DISCUSSION

1. THE ACQUISITION AND ENHANCEMENT OF STUDENTS' CREATIVE THINKING IN PHYSICS LESSON USING OER-ASSISTED PBL

This current study has proved that the implementation of OER-assisted PBL has a significant effect on the acquisition of students' creative thinking in physics lesson. Moreover, this study revealed that there is significant difference of the acquisition of creative thinking between students who study using OER-assisted PBL and students who study using DI. In addition, descriptively the acquisition of students' creative thinking in OER-assisted PBL classroom is higher than the acquisition of students' creative thinking in DI classroom. This proves that the implementation of OER-assisted PBL is exactly effective on the acquisition of students' creative thinking in physics lesson. Some previously relevant studies also revealed that the implementation of PBL assisted by OER, such as e-book, e-module, and web-based environment had significant positive effect on the acquisition of students' physics achievement [48-50, 53]. Additionally, a few of previously relevant studies also found that the implementation of OER-assisted PBL had significant positive effect of the acquisition of students' critical thinking [57], [58]. These reports provide strong evidences that the implementation of OER-assisted PBL is exactly effective on the acquisition of students' creative thinking in physics lesson.

Furthermore, this recent study also has proved that the implementation of OER-assisted PBL has a significant effect on the enhancement of students' creative thinking in physics lesson. Moreover, this study revealed that there is significant difference of the enhancement of creative thinking between students who study using OER-assisted PBL and students who study using DI. In addition, descriptively the enhancement of students' creative thinking in OER-assisted PBL classroom is higher than the enhancement of students' creative thinking in DI classroom. This proves that the implementation of OER-assisted PBL is exactly effective on the enhancement of students' creative thinking in physics lesson. Several previously relevant studies also revealed that the implementation of OER-assisted PBL significantly enhanced students' physics achievement [50-52, 104]. Additionally, a few of previously relevant studies also found that the implementation of OER-assisted PBL significantly enhanced students' critical thinking [57, 58]. These reports provide strong evidences that the implementation of OER-assisted PBL is exactly effective in enhancing students' creative thinking in physics lesson.

The implementation of PBL using OER can improve students' creative thinking in that students are accustomed to understanding the concepts to learning [72]. They actively search and find the knowledge autonomously both in groups and individually. Moreover, OER-assisted PBL makes physics lesson meaningful for students and their knowledge is acquired based on the schemes that students have [74]. Additionally, they can change perspectives or their way of thinking easily, they produce various answers/ideas or change them. They also provide various interpretations for an image, story, or problem. Subsequently, they think about different ways to solve a problem [73]. OER-assisted PBL requires students to find out solution alternatives for a problem both in groups and individually [76]. To have scientific interactions and thought exchanges in building knowledge collaboratively, learning is done in groups, and there are clear task divisions and clear objective determination. Teachers function as facilitators, monitor students' activity developments, and encourage them to achieve the targets [75]. Particularly, a few literatures also stated that PBL as a learning approach which starts a certain topic using the complex problem and enables that it has more than one solution in which all of these are directed to facilitate the enhancement of problem-solving, critical thinking, and creativity [72-74]. Therefore, OER-assisted PBL is one of the alternative ways to optimize students' creative thinking in physics learning.

2. *THE ACQUISITION AND ENHANCEMENT OF STUDENTS' CREATIVE THINKING IN PHYSICS LESSON VIEWED BY THE LEVEL OF STUDENTS' SELF-EFFICACY*

This recent study found that the level of students' self-efficacy has a significant effect on the acquisition of students' creative thinking skills in physics lesson. Additionally, the level of students' self-efficacy has a significant effect on the enhancement of students' creative thinking skills in physics lesson. Some relevant empirical studies also revealed that students' self-efficacy level had an essential role on the acquisition and enhancement of students' physics achievement in the learning environment of OER-assisted PBL [49, 50, 52-54]. Moreover, a few of relevant empirical studies found that the level of students' self-efficacy had an important role on the the acquisition and enhancement of students' critical thinking in physics lesson using OER-assisted PBL [57-58]. These reports strengthen that the level of students' self-efficacy has a significant role on the acquisition and enhancement of students' creative thinking in physics learning.

Furthermore, this current study also revealed that there is no significant interaction effect between learning model (OER-assisted PBBL and DI) and the level of self-efficacy on the acquisition of students' creative thinking skills in physics lesson. In addition, there is no significant interaction effect between learning model (OER-assisted PBBL and DI) and the level of self-efficacy on the enhancement of students' creative thinking skills in physics lesson. This means that students' self-efficacy level and learning model used like OER-assisted PBL are not jointly related to the acquisition and enhancement of students' creative thinking in physics lesson. In a literature, Damayanti and Yohandri [49] stated that although the level of students' self-efficacy has a significant role on the acquisition and enhancement of students' physics achievement in physics learning but it is not depended on the learning model used either OER-assisted PBL or DI. Moreover, a few of relevant empirical studies revealed that the implementation of learning models, such as OER-assisted PBL and DI had a significant effect on the optimization of students' creative thinking in physics lesson but it is not simultaneously affected by the level of self-efficacy that students have [50, 54]. These reports provide strong evidences to state that students' self-efficacy level and learning model used like OER-assisted PBL are not jointly related to the acquisition and enhancement of students' creative thinking in physics lesson.

3. IMPLICATIONS TO PHYSICS EDUCATION

This recent study has justified that OER-assisted PBL is one of alternative interventions to optimize students' creative thinking in physics lesson. Consequently, educational practitioners in the field of physics education, such as lecturer and teacher can implement PBL assisted by OER, such as e-book, e-module, web-based environment, etc., to optimize students' creative thinking abilities or skills in which they can enhance their creative thinking, so getting the high achievement in physics subject. Additionally, this current study also has examined that the level of students' self-efficacy has a significant role on the acquisition and enhancement of students' creative thinking in physics learning, even though it is not related to the learning model used as an intervention. This implicates to physics lecturers or teachers that they have to consider students' self-efficacy level as one of the important factors in optimizing students' creative thinking in physics learning.

4. LIMITATION AND SUGGESTION

There are some limitations of this study and several following suggestions are expected to minimize the limitations in the future researches. Firstly, sample size involved in this study tends to be small in which it is not so strong in estimating the population as the generalization function. Consequently, the relevant future researches should involve the large sample size, so it can precisely describe and estimate regarding the generalization of population. Secondly, it is difficult to apply random assignment in this quasi-experimental research in that it is related to the regulation of each school institution. As a consequence, the researchers in the relevant future studies have to find the solution of this gap, and discuss it with the educational authorities. Thirdly, it is also difficult to ensure that there are no other variables which indirectly have significant effect on the optimization of students' creative thinking beside the intervention of OER-assisted PBL and also self-efficacy. Therefore, the researchers in the relevant future researches as long as they can make sure some other factors which also have an indirectly potential impact on the optimization of students' creative thinking in physics lesson.

This recent study provides some description and analysis results connected to the application of OER-assisted PBL on the optimization of students' creative thinking viewed by the degree of students' self-efficacy. Firstly, most of students in the classroom of OER-assisted PBL and DI tend to have low and moderate self-efficacy in physics lesson but overall, students' self-efficacy in OER-assisted PBL classroom was higher than students' self-efficacy in DI classroom. Secondly, there is a significant different of the acquisition of creative thinking in physics lesson between students who study using OER-assisted PBL and students who study using DI in which to optimize pupils' creative thinking in physics lesson, the use of OER-assisted PBL is more effective than the use of DI. This justifies that here is a significant benefit from the application of OER-assisted PBL on the acquisition of students' creative thinking in physics lesson. Thirdly, there is a significant different of the enhancement of creative thinking in physics lesson between students who study using OER-assisted PBL and students who study using DI whereby to maximize the physics class's creative thinking from the students, the use of OER-assisted PBL is more effective than the use of DI. This also justifies that there is a significant positive effect of the implementation of OER-assisted PBL on the enhancement of students' creative thinking in physics lesson. Fourthly, the level of students' self-efficacy has a significant effect on the acquisition and the enhancement of students' creative thinking skills in physics lesson. Fifthly, the learning model and its interaction do not significantly affect each other (OER-assisted PBBL and DI) and the degree of self-efficacy on the acquisition and the improvement of students' creative thinking skills in physics lesson. Although the level of students' self-efficacy has a substantial role on the acquisition and enhancement of pupils' creative skill in physics learning but it is not depended on the learning model used either OER-assisted PBL or DI.

VI. CONCLUSION

This recent study provides some description and analysis results connected to the application of OER-assisted PBL on the optimization of students' creative thinking viewed by the degree of students' self-efficacy. Firstly, most of students in the classroom of OER-assisted PBL and DI tend to have low and moderate self-efficacy in physics lesson but overall, students' self-efficacy in OER-assisted PBL classroom was higher than students' self-efficacy in DI classroom. Secondly, there is a significant different of the acquisition of creative thinking in physics lesson between students who study using OER-assisted PBL and students who study using DI in which to optimize pupils'

creative thinking in physics lesson, the use of OER-assisted PBL is more effective than the use of DI. This justifies that here is a significant benefit from the application of OER-assisted PBL on the acquisition of students' creative thinking in physics lesson. Thirdly, there is a significant different of the enhancement of creative thinking in physics lesson between students who study using OER-assisted PBL and students who study using DI whereby to maximize the physics class's creative thinking from the students, the use of OER-assisted PBL is more effective than the use of DI. This also justifies that there is a significant positive effect of the implementation of OER-assisted PBL on the enhancement of students' creative thinking in physics lesson. Fourthly, the level of students' self-efficacy has a significant effect on the acquisition and the enhancement of students' creative thinking skills in physics lesson. Fifthly, the learning model and its interaction do not significantly affect each other (OER-assisted PBBL and DI) and the degree of self-efficacy on the acquisition and the improvement of students' creative thinking skills in physics lesson. Although the level of students' self-efficacy has a substantial role on the acquisition and enhancement of pupils' creative skill in physics learning but it is not depended on the learning model used either OER-assisted PBL or DI.

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Author Contributions

Agung Sedayu investigated the research gap (students' low creative thinking in physics lesson) and constructed the solution (OER-assisted PBL), and also prepared and designed a few of instruments, such as creative thinking test and self-efficacy questionnaire. Herpratiwi and Dwi Yuliyanti organized the experiment and collected the data related to students' pre and post creative thinking and students' self-efficacy in physics lesson. I Wayan Distrik analyzed the data and interpret it. Each author contributed to the completion of the final manuscript.

Conflict of Interest

Authors declare that there is no conflict of interest in this study.

Institutional Review Board Statement

The Ethical Committee of the Educational Authority of Lampung, Indonesia has granted approval for this study on November 1st, 2023 (Ref. No. 122/UN26.13/PN.01/2023).

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