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### ANALYSIS DESIGN STUDENT CRITICAL ABILITY WITH PROBLEM- BASE LEARNING AND PROJECT-BASED LEARNING MODELS (CASE STUDY IN JOMBANG INDONESIA)

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#### ABSTRACT

The critical thinking ability of students in the 2017 Entrepreneurship class of Economics Education Study Program STKIP PGRI Jombang is still low as indicated by the many students who master one aspect of learning, which is memorization. This study aims to explain the differences in students' critical thinking skills in the final measurement (post-test) and explain the difference in the increase (gain) of students' critical thinking skills between the PBL model class and the PjBL model. This research method uses a quantitative approach with a quasi-experiment method. The experimental research design uses "non-Equivalent group pretest-posttest design". The research variables include independent variables namely the PBL model and the PjBL model and the dependent variable is critical thinking ability. The data analysis technique uses different tests through an independent sample T-test. The results showed there were differences in students' critical thinking abilities using the PBL and PjBL models by 0.026 and there were differences in the increase (gain) in students' critical thinking skills between those using the PBL models and the PjBL models by 0.010. There is a difference in the increase (gain) of students' critical thinking skills between the PBL model class and the PjBL model class. It is recommended that the application of the PBL and PjBL models need to pay attention to the suitability of teaching materials, the availability of facilities and infrastructure, as well as the time allocation

#### INTRODUCTION

STKIP PGRI Jombang is one of the tertiary institutions or one of the higher education institutions that is expected to be able to create professional and

quality Human Resources. Higher education institutions as one of the mediators and facilitators in building the nation's young generation should teach, educate, train, and motivate their students to become intelligent generations who are independent, creative, innovative, and able to create various job opportunities / Entrepreneurs [1].

Students as the younger generation who have a broader and deeper mastery of the concept of knowledge do not seem to have done well. Based on the observation results, there are still many students who master one aspect of learning in the scope of thinking ability in memorizing aspects. The ability to think critically is one of the competencies that must be achieved as well as the tools needed to develop the lecture process in the class [2]. Problem-solving skills are very important for students in their profession and career success [3]. The learning process needs to be implemented optimally to improve students' abilities in solving problems in entrepreneurship courses. This can be done by learning oriented to various problems that show a picture of the world of work to stimulate the thought process [4].

Teaching and learning activities in higher education are more focused on the ability of students themselves. Lecturers are only facilitators and motivators in the learning process. However, this expectation has not been optimally achieved so far, this can be seen from the teaching and learning process which is still conventional / lecturer-centered. Students are accustomed to listening to lecturers deliver material while students just sit and listen. One-way learning like this will not be able to empower students' ability to think critically. Based on the fact that took place until now Teaching and Learning Activities carried out in class have not been fully able to increase students' mastery of thinking optimally, especially the ability to learn in the orientation of knowledge into daily life[5]. This is because the learning process is only directed at the ability of students to memorize and receive information alone, without being involved in understanding information that can be used in connecting the concepts of knowledge gained in everyday life.

Based on the results of observations on entrepreneurship courses, the average results of tests, quizzes, or daily tests in the form of pre-test and test posts are still many students who are less able to apply the material received in the real situation. This is because in delivering entrepreneurial material is still theoretical so it makes it difficult for students to understand the material taught thoroughly, as a result when students are given tasks oriented to the application of concepts and problem-solving in the field of one of the examples of Business Plan assignments, there are still many students who do not understand the intent and the assignment is given and how it means.

Besides the low ability of students to think critically is shown by the lack of student initiative to ask questions and answer when confronted with various problems that require critical thinking processes and problem-solving in Entrepreneurship courses. Besides, problem-solving activities help students to construct new knowledge and facilitate science learning [6]. To face the chal-

lenges of the era of the industrial era 4.0, lecturers should prepare students to be investigators, problem solvers, critical and creative minds [4].

The quality of learning increases optimally and achieves learning goals, a lecturer is required to be able to apply learning models that can foster the ability to think critically, creatively, analytically, systematically, and logically. Learning models that can activate and develop students' critical thinking skills are the Problem Based Learning (PBL) and Project-Based Learning (PjBL) models. Both of these models can train and encourage students to think and work rather than just memorizing and telling stories. This certainly will develop skills and make students think critically.

## **METHODS**

In implementing scientific method research, the steps of conducting research must be planned, systematic, and explicit. But the same steps cannot be made in all types of research, because of differences in objectives, objects, and problems, [7]. This study reveals the difference between the use of Problem Based Learning (PBL) and Project-Based Learning (PjBL) learning models for students' critical thinking skills in entrepreneurship courses. This uses a quantitative approach with the quasi-experimental method. Where the research sample is not randomly grouped but accepts the state of the sample as is [8]. Research design This experiment used "non-Equivalent group pretest-posttest design". The sample used 80 students who were divided into 2 groups,  $n = 40$  using the PBL model and  $n = 40$  using the PjBL model.

The research variables include independent variables in the form of PBL and PjBL models and the dependent variable in the form of critical thinking skills. The data analysis technique uses different tests through an independent sample T-test. This aims to see the difference in the ability to think critically students who use the PBL model and PjBL models in the 2017 class of entrepreneurship courses in the STKIP PGRI Jombang Economic Education Study Program.

## **RESULT**

### ***Pre-test description***

Pre Tests were given to two groups of research subjects namely the PBL group and the PjBL group. To test the research hypothesis, the normality of the data class of the research class must be tested as a prerequisite in the calculation of parametric analysis. With the research instrument in the form of a description test of 6 question. Based on the data processing of the pre-test results in the PBL and PjBL groups, the following results were obtained. The results of the Pretest Data Analysis of PBL and PjBL classes

**Table 1.** Description of the Initial Test (Pre Test)

Class	n	Xmin	Xmax	Mean	SD
PBL Model	40	70	95	81,95	6,34
PjBL Model	40	62	98	80,30	7,80

Based on table 1 above, the class that uses the Problem Based Learning (PBL) model have 40 students who gained an average of 81.95 with the highest score of 95 and the lowest score of 70 with a Standard Deviation of 6.34. Whereas the class that uses the PjBL model has 40 students, an average of 80.30 with the highest score of 98, and the lowest score of 62 Standard Deviations of 7.80.

### *Post test descriptions*

Post Test is a test given to students after being given treatment. With different treatments, and obtained quite different results between classes using the PBL model and those using the PjBL model. To see an increase in students' critical thinking skills, the posttest was held both in the PBL class and the PjBL class. From the results of processing the final test data (posttest) obtained data as follows. PBL and PjBL Class Posttest Data Analysis Results.

**Table 2.** Description of the Final Test (Post Test)

Class	n	Xmin	Xmax	Mean	SD
PBL Model	40	82	100	92,43	5,35
PjBL Model	40	80	100	89,65	5,58

Based on table 2 above, the class that uses the Problem Based Learning (PBL) model has 40 students who gained an average of 92.43 with the highest score of 100 and the lowest score of 82 with a Standard Deviation of 5.35. Whereas in the class that uses the PjBL model has 40 students gained an average of 89.65 with the highest score of 100 and the lowest score of 80 Standard Deviation of 5.58

### *Experiment class and control class N-Gain test*

To find out the increase in students' critical thinking skills by using the Problem Based Learning (PBL) model and the use of the Project-Based Learning (PjBL) model, the Kolmogorov-Smirnova normalized gain calculation is used. From the results of the N-GAIN data analysis, it can be seen from Table 3 below.

**Table 3**N-Gain Test PBL Model and PjBL Model

Class	Pre Test	Post Test	N-Gain %	Information	N-Gain Score	Criteria
PBL Model	81,95	92,43	62,37	Effective enough	0,62	enough
PjBL Model	80,30	89,65	48,76	Less effective	0,49	enough

**Table 3** above, the pretest and posttest data values obtained gain in the PBL class of 62.37 and are in the criteria quite effective than the gain value in the PjBL class is 48.76 and are in the less effective criteria. The following table categories the interpretation of N-Gain Effectiveness.

**Table:4.** Categories of Interpretations of N-Gain Effectiveness

Percentage (%)	Interpretation
< 40	Ineffective
40 – 55	Less effective
56 – 75	Effective enough
> 76	Less effective

**Source:** Hake, R.R, 1999

### *Test Statistics Requirements*

#### *Normality test*

To test the normality of data in this study using Kolmogorov-Smirnova). The results of the normality test of the pretest and posttest frequency distribution in the class using the Problem Based Learning (PBL) model and the class using the Project-Based Learning (PjBL) model with significant level testing  $\alpha = 0.05$  and degrees of freedom = 3, as for the provisions as the following:

If the verification is  $<0.05$  then the data are not normally distributed.

If the significance is  $> 0.05$  then the data is normally distributed. The results of calculating the normality of data, the researchers more clearly present in the form of a table below:

**Table 5** Data Normality Test

Statistics	PBLModel		PjBLModel	
	Pre Test	Post Test	Pre Test	Post Test
Mean	81,95	92,43	80,30	89,65
Primary school	6,34	5,35	7,80	5,58
Sig (Shapiro-Wilk)	0,320	0,085	0,709	0,100
$\alpha$	0,05			
Information	Normal	Normal	Normal	Normal

If Significant < 0.05, it is said that the data distribution is not normal

If Significant > 0.05, it is said that the data distribution is normal

Based on the Test of normality table, it is known that the variable of critical thinking ability of PBL and PJBL students before being given treatment (pre-test) has Sig values of 0.320 and 0.709, greater than 0.05, so it is said that the data distribution is normal. While the critical thinking skills of PBL and PPA class students after being treated (post-test) have Sig values of 0.085 and 0.100, respectively, greater than 0.05 so that it is said that the distribution of normal data

### *Homogeneity test*

Based on the results of normality testing shows that the two data in each class are normally distributed, and then it is necessary to test the homogeneity of the data. The aim is to find out whether the data obtained from the two groups have homogeneous variance or not. Homogeneity test results were performed using the Levene statistical test the results of the pretest and posttest homogeneity tests of the two groups can be seen in the table as follows:

**Table 6** Data Homogeneity Test

Statistics	Pre Test		Post Test	
	PBLModel	PjBLModel	PBLModel	PjBLModel
F count it	1,529		0,011	
Sig (Levene Test)	0,220		0,918	
$\alpha$	0,05			
Information	Homogen		Homogenous	

If Sig < 0.05, it is said that the data is not homogeneous

If Sig > 0.05, it is said to be homogeneous data

Based on the Test of Homogeneity of Variances table, it is known that the variable of critical thinking ability of students before being given a significant value of 0.220 > 0.05 is said to be homogeneous data. After being given the variable treatment of critical thinking ability of students after being given a significant treatment value of 0.918 > 0.05 it is said to be homogeneous data.

### *Pre-test*

The results of the initial ability test (pretest) with the t-test through Independent Samples T-test obtained the following results

**Table 7** Pre-Test

Class	Mean	T Count	Significant	$\alpha$	Information
PBL Model	81,95	1,039	0,302	0,05	Not Significant
PjBL Model	80,30				

Note not significant means there is no difference in initial ability

Based on table 7 above Sig (2-tailed) it is known that for the variable critical thinking ability of students before being treated has a value of  $0.302 > 0.05$  it is said to be insignificant meaning there is no difference in students' critical thinking skills before being given treatment.

### *Hypothesis testing*

#### *Hypothesis test final test (Post-Test)*

A difference test of two means in the posttest was conducted to test the hypothesis whether there were differences in the final posttest learning test which used the PBL model and which used the PjBL model. The decision criteria for the t-test are as follows:

Sig  $< 0.05$ , then it says there is a difference

Sig  $> 0.05$ , it says there is no difference

**Table 8.** Hypothesis Test (T-Test) Final Test (Post Test)

Class	Mean	T Count	Sig	$\alpha$	Information
PBL Model	92,43	2,270	0,026	0,05	Significant
PjBL Model	89,65				

Note significant means there are differences in the final ability

Based on table 8 above Sig (2-tailed) it is known that the variable of critical thinking ability of students after being treated has a value of  $0.026 < 0.05$ , it means that there is a difference in the ability to think critically students after being given treatment.

### *Gain Hypothesis Test*

A difference test of two averages in the N-Gain data is carried out to test the hypothesis namely whether there is a difference in the increase (gain) of learning in the class using the PBL model compared to the class using the PjBL model.

**Table 9** Gain Hypothesis Test

Class	Mean	T Count	Sig	$\alpha$	Information
PBL Model	62,37	2,648	0,010	0,05	Significant
PjBL Model	48,76				

Note significant means there are differences in the increase in critical thinking skills

## DISCUSSION

### *Problem based learning*

Rusman[9], states that one alternative learning model that allows students to develop thinking skills (reasoning, communication, and connections) in solving problems is Problem Based Learning (PBL). This means that the use of PBL is very potential to develop themselves through student's meaningful problem-solving[10][11].

Educators want students to acquire creative and critical thinking skills during learning activities so that they can overcome complex problems in daily life. Therefore PBL is applied to improve students' creative and critical thinking skills, for example, Chan [12], says that PBL increases the critical thinking and creativity of nursing students, and Nargundkar, Samaddar, and Mukhopadhyay [6], determine that PBL effectively enhance critical thinking of business school students. PBL is one of the learning models that places students as the center of learning. PBL teaches students to think critically and logically in solving problems based on the knowledge they already have[13][14]. "PBL will encourage students to look for alternative solutions to problems that are has been given, then students/students are asked to choose the best solution used in solving existing problems[15]. PBL is an approach to learning by making confrontation with learners with practical problems or learning that starts with giving problems and has a context with the real world"[16]. Furthermore, Amir [17] said that PBL is a learning model that challenges students to learn to learn, work together in groups to find solutions to real problems. Based on the explanation, it can be concluded that PBL is a learning model that can encourage and stimulate students to learn to find solutions to a practical problem in the learning process[18]. In solving a problem, there must be a scientific stage that must be passed by students/students. The steps that must be passed are aimed so that students can learn knowledge related to the problem and at the same time have the skills to solve problems[19]. According to Rusman [9], the steps that must be taken in PBL are as follows:

According to Wina Sanjaya [20], there are three main characteristics of PBL, namely: (1) PBL is a series of learning activities, meaning that in its implementation there are many activities that students must undertake. PBL does not expect students to just listen, take notes, then memorize subject matter, but through student/student models actively think, communicate, search and process data, and finally conclude. (2) Learning activities aimed at solving problems. (3) Problem-solving is done by using a scientific approach to thinking with the process of deductive and inductive thinking. Problem-solving must go through certain stages and must also be based on data and facts.

### ***Project-based learning***

The PjBL learning model is a learning model that involves project work for students/students. The PjBL learning model provides an opportunity for the teacher to manage the class differently. It is widely used to replace traditional teaching methods where teachers as a center of learning[21]. The PjBL model, students are asked to think critically and scientifically, and also require stu-

dents to study independently. Because the PjBL provides a real learning situation for students, ie students are asked to work on a project that will later provide permanent knowledge. PjBL is a learning model with a constructivist approach. This approach requires students to learn independently and can plan and carry out their learning or collaborate with teachers/lecturers and other students/students. According to [16]

PjBL is a student-centered strategy that encourages initiative and focuses students on the real world and can increase motivation. Based on some of these descriptions, it can be concluded that the model This learning can encourage students to be more creative, active, and independent in solving a problem in the form of a project that must be completed. This project also provides tangible learning and skills for students. It has been explained previously that PjBL is a systematic learning model. In other words, some rules and steps must be followed in implementing this learning. Sutirman [22] explains the steps of the PjBL as follows:

- a. Learning begins with essential questions, namely questions that encourage students to carry out activities
- b. Students/students accompanied by the teacher/lecturer create a project design that will be done. The project plan is determined by students/students themselves and refers to the essential questions that have been raised previously.
- c. Teachers / Lecturers and students/students collaboratively arrange a schedule for the implementation of learning activities. What needs to be done at this stage include: (1) making a schedule for completing the project, (2) making a deadline for completing the project; (3) directing students to plan new ways of completing projects; (4) directing students/students when they make ways that are not related to the project and (5) asking students/students to give reasons about the chosen method
- d. Teachers / Lecturers constantly monitor student activities during project completion to find out progress on project implementation and anticipate obstacles faced by students/students
- e. The assessment is carried out to measure the achievement of standards, evaluate the progress of each student/student, provide feedback on the level of understanding that has been achieved, and be considered in developing the next learning strategy.
- f. At the end of the lesson a reflection of the results of the project that has been carried out. This process is carried out individually and also in groups.

Based on the explanation that has been done, both models will be applied in the learning process. The two models expect to be able to make students more active, creative, independent, and also think scientifically and logically in learning. Because both models are in line with the constructivism approach.

Based on research conducted by Setyorini [23] explained that PBL can improve students' thinking skills. This is expected to improve student learning outcomes as well. While Muh Rais (2010) in his research results explained

that the application of the PjBL model could significantly improve academic outcomes. This is because PjBL provides real learning in the form of projects that enable students to better understand the learning that is directly based on increasing learning outcomes.

The calculation results obtained significant value. (2-tailed) of  $0.010 < 0.05$  means significant. It can be concluded that there is a difference in the increase (gain) in the critical thinking skills of students between classes using the PBL model and those using the PjBL model. This can be seen from the average gain value between the experimental class and the control class where the average gain value for the class using the PBL model is higher when compared to the gain value in the class using the PjBL model.

Based on the results of tests given before the treatment (pretest), the average yield is not much different. This means that there is no difference in students' critical thinking skills at the initial measurement between the class using the PBL model and the class using the PjBL model. This can be seen from the value of significant  $0.302 > 0.05$

The final test results (posttest) obtained an average value for the class using the PBL model of 92.43 while the average value for the class using the PjBL model of 89.65. That is, there is a difference in students' critical thinking skills at the final measurement (posttest) between classes using the PBL model and the population using the PjBL model. This is indicated by the significant value of  $0.026 < 0.05$ . As for the gain data obtained by count significant  $0.010 < 0.05$  then  $H_2$  is accepted and  $H_0$  is rejected. That is, there is a difference in the increase (gain) of students' critical thinking skills between classes using the PBL model and classes that use the PjBL model.

Critical thinking can be seen as the ability of students to compare two or more information possessed. If there are differences or similarities, then students will ask questions or comments to get an explanation. The ability to think critically reflects the ability to make a rational judgment in using concrete evidence.

The results of the study explained that PBL and PjBL learning models were able to improve students' critical thinking skills. Using the right learning model, students can develop thinking skills[24]. PBL and PjBL learning models give students the freedom to process all the knowledge they have and find new knowledge needed so that new knowledge is formed by students themselves as a result of the process of linking old knowledge and new and can explain the relationship between the PBL Learning Model and the PBL learning model[25][15].

The results of this study are in line with research conducted by YN Nafiah [26] saying that the PBL model can improve the mastery of concepts, problem-solving abilities, communication skills, critical thinking skills, creative thinking, and can foster character. Besides, based on research conducted by

Isnania [27] states that the PBL model can significantly improve students' critical thinking skills. This research is also supported by Kani Ulger [28] saying that using the PBL model approach can support the development of critical thinking skills of students in various disciplines.

Based on the analysis of N-gain data it is seen that the PBL class gain is higher when compared to the PjBL class, even though they are at the medium criteria. This is because with PBL learning students can integrate knowledge and skills simultaneously and apply them in real and relevant contexts. That is, what students do following real conditions is no longer a theory so that various problems in the application of theory students will find during learning takes place. Therefore, learning in the PBL model takes place authentically.

According to the researcher's observations, another thing that causes differences in students' critical thinking skills between the two classes is the PBL model. It starts with a problem presentation for students to solve or learn more about. Often these problems are framed in scenarios or case study formats. Problems are designed by mimicking the complexity of problems in real life.

Learning assignments also vary greatly in scope, time, and sophistication. Learning outcomes are only solutions in the form of writing or presentation; the examples carried out in learning are divided into two parts, namely learning in the classroom and carried out independently filled with discussion activities regarding the preparation of a Business Plan to be undertaken by students and literature review that utilizes the current technological sophistication, like the internet. Based on observations, learning in the classroom is going well. Students intensely ask various questions to lecturers who act as facilitators.

Learning outside the classroom is done by students independently. Students carry out a show of Entrepreneurship (KWU) with full responsibility and grow creativity proven when there was a presentation about the results of the KWU degree performance many new and unexpected experiences experienced by students, although not all students succeeded in working on the KWU degree performance following the targets given by the lecturers. Besides, students also find various problems in the KWU degree show they are working on that will make them try to solve those problems and the solutions they find can be useful if they experience the same or slightly different problems. Of course in solving a problem and question, indirectly students are required to always think critically.

One of the goals of PBL is to connect the knowledge acquired by students in the class to be applied in the real world by making solutions to existing problems - where students also act as professions in the real world. Besides, PBL must be able to provide benefits to the surrounding community where this is the main essence of educational goals.

Learning activities experienced by students will be very meaningful in their lives, where students will always remember important points in their learning.

Besides, the PBL learning model will provide skills on how to become life-long learning for students, and this knowledge will be very useful to be able to survive in competition in the knowledge-based economic era.

The application of PBL and PjBL models has constraints on time allocation because this model involves students from the beginning of learning, which starts from the planning stage to the end of learning so that it requires relatively more time. Besides, in applying the PBL and PjBL models lecturers must adjust to the material to be studied and should use a variety of models.

The PBL and PjBL models are equally focused on questions/assignments that are open, authentic learning, student-centered, multi-disciplinary, focus on strengthening independent learning skills, communication, collaboration, critical thinking, time management, and skills project management. Therefore, this learning model can be used as an alternative learning model for improving students' critical thinking skills.

## CONCLUSION

There are differences in student's critical thinking skills increase (gain) of students' between the class using the PBL model and the class using the PjBL model. The role of the lecturer as a facilitator must regulate the course of the learning process following the stages of each step of the PBL and PjBL learning model implemented by students.

## REFERENCES

- Anna Marganingsih, Salniyati, (2016), The Influence of Chemo-Entrepreneurship and Media Edutainment Approaches Against the Ability to Detect Business Opportunities in Students of the Economics Study Program Persk Khatulistiwa Sintang, Jurkami: Journal of Economic Education, [Http://Jurnal.Stkippersada.Ac.Id/](http://Jurnal.Stkippersada.Ac.Id/) Journal / Index.Php / Jpe, Jurkami Volume 1, No 2, 2016.
- I Husnidar, "M., & Rizal, S.(2014). Application of the PBL Model to improve critical thinking skills. Syah Kuala University, Banda Aceh.J. Didakt. Mat., vol. 1, no. 1, pp. 71–82.
- M.-Q. Duong, "Analytical Evaluation of College Learning Experiences on Students' Problem-Solving Efficacy among Technical and Scientific Areas," *Int. J. Eval. Res. Educ.*, vol. 1, no. 2, pp. 67–72, 2012.
- Munawaroh, "The Effect of Problem-Based Learning (Pbl) Method on Students Critical Thinking Skills on Entrepreneurship Practice Course (a Study on Economics Education Department in the College of Education and Teachers' Training Pgri Jombang East Java Indonesia)," *J. Entrep. Educ.*, vol. 21, p. 1, 2018.
- Y. Suryani and S. Mulyati, "The Effect Of Use Project Based Learning Methods On Study Critical Thinking Ability ( Experiment Study Education Program Economic ," *Equilibrium*, vol. 13, no. 1, 2016.
- R. Mukhopadhyay, "Problem solving in science learning-some important considerations of a teacher," *IOSR J. Humanit. Soc. Sci.*, vol. 8, no. 6, pp. 21–25, 2013.

- Q. Sholihah, ). "Introduction to Research Methods", University Of Brawijaya Press, 2019.
- E. T. Ruseffendi, "Fundamentals of Educational Research in Other Non-exact Sciences Fields," Bandung: Tarsito, 2005.
- Rusman, Learning Models, Rajawali Pers/PT Raja Grafindo Persada, 2011.
- R. Maskur et al., "The effectiveness of problem based learning and aptitude treatment interaction in improving mathematical creative thinking skills on curriculum 2013," *Eur. J. Educ. Res.*, vol. 9, no. 1, pp. 375–383, 2020.
- J. High, "The Effect of Problem-Based Learning Strategies and Cognitive Styles on," vol. 13, no. 4, 2020.
- Z. C. Y. Chan, "Exploring creativity and critical thinking in traditional and innovative problem-based learning groups," *J. Clin. Nurs.*, vol. 22, no. 15–16, pp. 2298–2307, 2013.
- C. M. Haley and B. Brown, "Adapting problem-based learning curricula to a virtual environment," *J. Dent. Educ.*, no. May, pp. 1–2, 2020.
- G. Kassymova, A. Akhmetova, M. Baibekova, A. Kalniyazova, B. Mazhinov, and S. Mussina, "E-Learning Environments and Problem-Based Learning," vol. 29, no. 7, pp. 346–356, 2020.
- W. Malmia et al., "Problem-based learning as an effort to improve student learning outcomes," *Int. J. Sci. Technol. Res.*, vol. 8, no. 9, pp. 1140–1143, 2019.
- G. Gunantara, I. M. Suarjana, and P. N. Riastini, "Application Of The Problem Based Learning To Improve The Mathematical Problem Solving Ability Of Class V Elementary Students," *Mimb. PGSD Undiksha*, vol. 2, no. 1, 2014.
- M. T. Amir, Education Innovation Through Problem Based Learning. Prenada Media, 2016.
- L. Mann et al., "From problem-based learning to practice-based education: a framework for shaping future engineers," *Eur. J. Eng. Educ.*, vol. 0, no. 0, pp. 1–21, 2020.
- H. Tadjer, Y. Lafifi, H. Seridi-Bouchelaghem, and S. Gülseçen, "Improving soft skills based on students' traces in problem-based learning environments," *Interact. Learn. Environ.*, vol. 0, no. 0, pp. 1–18, 2020.
- W. Sanjaya, "Standardized Learning Process Oriented Education Process," Jakarta Prenadia Group, 2019.
- R. Munawaroh, B. Subali, and A. Sopyan, "Application of Project Based Learning and Cooperative Models to Build the Four Pillars of Student Learning," *UPEJ Unnes Phys. Educ. J.*, vol. 1, no. 1, 2012.
- M. P. Sutirman, "Media And Innovation Learning Models," Yogyakarta Graha Ilmu, 2013.
- U. Setyorini, S. E. Sukiswo, and B. Subali, "Application Of Problem Based Learning Models To Improve Critical Thinking Ability Secondary Students," *J. Pendidik. Fis. Indones.*, vol. 7, no. 1, 2011.
- O. L. Ng, F. Ting, W. H. Lam, and M. Liu, "Active Learning in Undergraduate Mathematics Tutorials Via Cooperative Problem-Based Learning and Peer Assessment with Interactive Online Whiteboards," *Asia-Pacific Educ. Res.*, vol. 29, no. 3, pp. 285–294, 2020.

- R. M. Lopes et al., "Principles of Problem-Based Learning for Training and Professional Practice in Ecotoxicology Laboratório de Comunicação Celular , Instituto Oswaldo Cruz , Fundação Oswaldo Laboratório de Avaliação e Promoção da Saúde Ambiental , Instituto Oswaldo Cruz , L," 2019.
- Y. N. Nafiah and W. Suyanto, "Application of Problem-Based Learning Models to Improve Critical Thinking Skills and Student Learning Outcomes, Journal of Vocational Education 125," J. Pendidik. Vokasi, vol. 4, no. 1, 2014.
- I. Lestari and R. Juanda, "Comparative Model of Problem Based Learning and Project Based Learning Against Student Learning Outcomes in Internet Network Hardware Material Class IX SMP Negeri 5 Sungai Kakap Kubu Raya Regency, Effectors, Volume 6 Issue 2, 2019, Pages 127-135 Available online at <http://ojs.unpkediri.ac.id/index.php/efektor-ehttps://doi.org/10.29407/e.v6i2.13159>
- K. Ulger, "The effect of problem-based learning on the creative thinking and critical thinking disposition of students in visual arts education," Interdiscip. J. Probl. Learn., vol. 12, no. 1, 2018.