International Journal of Evaluation and Research in Education (IJERE)
Vol. 9, No. 2, June 2020, pp. 415~420
ISSN: 2252-8822, DOI: 10.11591/ijere.v9i2.20531

Project brief effects on creative thinking skills among low-ability pre-service physics teachers

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Article Info

Article history:

Received Feb 11, 2020
Revised Mar 21, 2020
Accepted May 1, 2020

Keywords:

Creative thinking skills
Low ability
Pre-service teachers
Project brief

ABSTRACT

Creative thinking is high-order thinking that is not easy to stimulate with conventional learning, especially to solve complex physics problems. However, the learning strategy chosen must be in accordance with the teaching materials and students characteristics. Creative thinking is very important especially for low-ability characteristic in solving complicated physics problems; therefore, it needs to be triggered by student-centered learning strategies such as project briefs. This research was to analyze the effect of project brief learning on creative thinking skills (CrTS) of low-ability pre-service physics theacers. Sample was selected using purposive sampling (97 people) in the initial semester pre-service physics teachers which consisted of three classes A (32 people), B (35 people), and C (30 people). Data collection through essay tests on vibration and wave material and adjusted according to the CrTS-Kim indicators. The results show that the project brief has a positive effect on creative thinking skills. The highest effect on the fluency indicator has an average of 15.7 compared to the lecture strategy, as well as the mixture with an average of 9.89, and the lowest on the originality indicator.

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1. INTRODUCTION

Most of the pre-service physics teachers in state universities are more qualified than private universities, especially in Indonesia [1]. It was because the passing grade at state universities was higher and more competitive. In 2019, the Ministry of Higher Education has tightened the admission process at state universities. This causes as many as 23% of 714,652 students accepted into state universities. Students who do not meet the requirements automatically enrolled in private universities are then categorized as low-ability students. This case is unique because it can affect student interest and learning ability in the lecture process [2], un-confidence [3], low motivation [4], and uninterested in learning [5]. However, in the theory of the education process, it is the educator's challenge to create an interesting, effective and enjoyable learning atmosphere [6]. Therefore, educators must be able to increase learning activities and motivation by using learning strategies that are motivating and learner-centered [7].

One of the student-centered learning strategies is project-based learning (PjBL) [8]. PjBL has two types, namely project brief and full. In lectures, the application of brief projects is considered because it is of short duration. This strategy has had a positive impact on improving critical and creative thinking skills

(CrTs) [9]. Previous research has presented various positive effects of project-based learning applications. Some of the representatives, Doppelt [10] found that learners have practiced documenting creative processes, teamwork, and reflection. In addition, to promote creativity and problem solving [11], strengthen self-confidence [12], improve learning achievement [13], and increase learning motivation [14]. Alacapınar [15] states that project learning can influence the originality of learners' thinking. However, originality is an indicator of creative thinking.

Project learning uses problems to trigger learning activities [16]. Boud and Feletti [17] said that problems can construct knowledge, and stimulate learning activities. Quality problems have a positive impact on knowledge and skills in each learning process and produce a variety of works [18]. However, the project brief emphasizes an in-depth process of understanding concepts through quality problems. Emphasis on each process is a strategy to train learners' creative thinking skills.

Creative thinking is a very important skill as a provision for current and future technological progress, even an indicator of the quality of education in countries around the world. In 2018, WEFFI has released a report that the quality of education in Indonesia ranks 43 out of 50 countries in preparing future skills, while Finland is the first. Finland has prioritized creative skills as one of the learning objectives in its curriculum. Creative thinking has been known as a divergent pattern of realistic thinking skills. Creative thinking allows one to connect problems from different perspectives and find unique solutions. Kim [19] has identified this thinking pattern through four indicators of fluency, flexibility, elaboration, and originality. The profile of indicators is as follows: 1) Fluency is the ability to create various unique ideas, 2) Flexibility is an indicator of the ability to express alternative problem solving, 3) Originality; the ability to solve problems with unique concepts, 4). Elaboration is the ability to detail various problems and solutions. Treffinger [20] said that all people have the potential to think creatively; therefore, it is important to choose the right strategy to be able to trigger it.

The application of the project brief is to stimulate the learning motivation of prospective physics teachers, especially those with low abilities. This study shows the effects of conventional strategies on creative thinking to compare their effects to the project brief. The expected impact is students become active and enjoy completing difficult and complex physics concepts. In the future, this strategy can be used as a reference in applying other learning models that are learner-centered.

2. RESEARCH METHOD

2.1. Research design

In social research, external effects cannot be fully controlled and random group assignments are not possible [21], therefore, this study uses quasi-experiment with pretest-post-test groups' design [22]. Design as follows in Table 1. This study compared three groups of experimental treatments *(O_1-O_1')* and controls *(O_2-O_2')* and *(O_3-O_3')* (Table 1). The experimental group was treated with the PjBL in the category of project brief and with conventional as control, namely lecture, and mixture (lecture and discussion). Treatments are given to examine the effect of creative thinking skills on each indicator simultaneously on basic physics concepts.

Table 1. Design the pretest-posttest groups

Pretest Groups	Treatment	Post-test groups
O_1	Project Brief Learning	O_1'
O_2	Lecture	O_2'
O_3	Mixture (Lecture and Discussion)	O_3'

Note: O_1- O_1': Experimental Groups, O_2- O_2', and O_3-O_3': Control groups

2.2. Sample

Sample was involved from one of the private universities in West Nusa Tenggara, Indonesia; therefore, their characteristics were categorized as low-ability. Samples were selected using purposive sampling totaling 97 people in the initial semester pre-service physics teachers which consisted of three classes A (32 people), B (35 people), and C (30 people). The purposive sampling technique is used because the sample used has its own characteristics [23]. Class A is assigned as an experimental group because it is treated with a project brief, while classes B and C use conventional learning strategies; therefore, it is assigned as a control class.

2.3. Instrument and data analysis

Data collection through essay tests on vibration and wave material. The score of student answers is adjusted according to the CrTS-Kim indicators. The effects of independent variables are simultaneously analyzed using Multivariate Analysis of Variance (Manova) by SPSS 18. Analysis of Manova has been chosen because the dependent and independent variables are more than two or meet the requirements [24]. Independent variables are the learning strategies of the project brief, lecture, and mixture, while the dependent variables are the four CrTs indicators according to Kim [19], namely: fluency, flexibility, originality, and elaboration. Manova analysis was carried out after fulfilled the prerequisite test, namely, normality and homogeneity.

3. RESULTS AND DISCUSSION

The following students' answers description to solve the wave problem seen based on fluency, flexibility, originality, and elaboration indicators. The question: "Ocean waves are formed by tectonic earthquakes where the wavelength and period are 20 meters and 4 seconds. How long does it take (seconds) to get to your house (Please assume the distance of the source to the shoreline is 1 kilometer so you can estimate the distance to your house). Describe the number of waves formed from the source to your home". Student 1 answer for indicators: *(a) fluency:* data information i.e. wavelength (λ) = 20 meters, period (T) = 4 seconds to complete travel time (t) to my home which is (x) = 1500 meters from the shoreline. The next goal is to measure the number of waves (n) from the source to my house, *(b) flexibility:* if velocity is constant then: λ / T = x / t, so the propagation time from the wave source to my house is t = x. T / λ or t_{total} = x_{total}. T / λ, *(c) originality:* t_{total} = x_{total}. T / λ = 2500x 4/20 = 500 seconds. While the number of waves formed is n = xtotal / λ or ttotal / T = 125 waves, *(d) elaboration:* The number of waves (n) can use a comparison of the wavelength (x) to wavelength (λ) or the ratio of travel time (t) and period (T). Wavelength is the distance of a hill and valley. This case explores students' creative thinking abilities through variations of answers from an assumption. Analyses of the answers for each score of creative thinking indicators are known through parametric tests.

Normality is needed to test assumptions as well as a prerequisite for parametric tests; therefore, data must be normally distributed. Data that is not normally distributed cannot be analyzed by parametric statistics [25]. Data requirements are normally distributed if sig. >0.05, [22]. The results in Table 2 shows that the pretest-posttest data carried out in classes A, B, and C are in sig. >0.05, therefore it is concluded that the data. Parametric analysis such as Discriminant and MANOVA requires a homogeneous variance-covariance matrix. The homogeneity requirement is used as a reference to determine the significant effect of the independent variable towards the dependent variable. The homogeneity test results are automatically presented at Manova output. Homogeneous conditions if the output at the Box's M and Levene's test has sig. > 0.05 [26]. The results show that the Box's M test (Table 3) and Levene's (Table 4) are in the sig. > 0.05, therefore the data has met the requirements of homogeneity.

Table 2. Normality of CrTS pretest-post-test indicators in each group

Variants	A		B		C	
	Sig	N	Sig	N	Sig.	N
Fluency	0.10	32	0.26	35	0.19	30
Flexibility	0.09		0.15		0.07	
Originality	0.11		0.09		0.40	
Elaboration	0.16		0.22		0.19	

Note: A: Project brief; B: Lecture; C: Mixture (Lecture and Discussion).

Table 3. Homogeneity of matrix variants (Box's M)

Test	Results	Conclusion
Box's M	20.550	Has been homogeneous
F	0.964	
Sig.	0.504	

Table 4. Homogeneity of variants (Levene's test)

Indicators	F	df1	df2	Sig.
Fluency	1.234	2	94	0.296
Flexibility	1.341	2	94	0.267
Originality	2.815	2	94	0.065
Elaboration	1.467	2	94	0.236

The simultaneous influence of the project brief and conventional learning strategies has been shown in the Multivariate test output (Table 5). Learning strategies that have been used have an effect on the independent variable when the sig value. < 0.05, [25]. The output results show that there are four types of tests suggested namely Pillai's trace, Lamda's wilks, Hottelling's Trace, and Roy's Largest Root which all meet the requirements if sig. < 0.05 (Table 5), however Wilks' Lamda should be chosen because there are more than two groups in the dependent variable. This indicates that there is a significant difference between the independent variables and the dependent variable simultaneously.

Table 5. Multivariate test

Effects of Learning Strategies	Value	F	df	Error df	Sig.
Pillai's Trace	.431	6.318	8	184.000	.00
Wilks' Lambda	*.582*	*7.067*	*8*	*182.000*	*.00*
Hotelling's Trace	.695	7.822	8	180.000	.00
Roy's Largest Root	.661	15.207	4	92.000	.00

Test the effect of the independent variables on the dependent variable (variants) simultaneously shown in the F test and significant at sig. <0.05. The results show that there are differences in the contribution of learning strategies to the CrTS indicator (Table 6). The effect of learning strategies on fluency indicators is 22% (highest than others). The contribution of learning strategies to indicators of flexibility, originality, and elaboration is 15%, 5.6%, and 6.9%. It means that, the effect of learning strategy simultaneously on each CrTS indicator has a difference. The difference in the average score from the confrontation of each learning strategy is presented in Table 7.

Table 6. Test of between subjects' effects

Variants	F	N	Sig.	Adjusted R square (%)
Fluency	15.02	97	0.000	22
Flexibility	9.655		0.000	15
Originality	3.855		0.025	5.6
Elaboration	4.578		0.013	6.9

Table 7. Post-hoc test

Variants	Multiple Comparisons					
	A versus B		A versus C		B versus C	
	Mean diff.	Sig.	Mean diff.	Sig.	Mean diff.	Sig.
Fluency	15.17*	0.00	9.89*	0.00	5.28	0.20
Flexibility	11.66*	0.00	5.11	0.20	6.55	0.05
Originality	5.00*	0.01	0.43	1.00	4.57	0.08
Elaboration	11.29*	0.02	0.97*	0.04	1.58	1.00

*Significant at level 0.05; A = Project brief; B = Lecture; C = Mixture

The difference in the average effect of the project brief versus the lecture and the mixture on fluency is 15.17 and 9.89. This indicates that the effect of the project brief is higher than the lecture and mixture specifically for fluency indicators. Likewise, the differences in the effect of the project brief versus lecture on flexibility, originality and elaboration indicators are 11.66, 5.0, and 11.29, while the project brief versus mixture is only significant on fluency (9.89) and elaboration (0.97). These results mean that the effect of project briefs has a more positive impact on the ability to produce various ideas (fluency) in solving physics problems. However, the project brief also contributes to improving flexibility, originality and elaboration abilities. All these indicators are students' creative thinking skills. According to Gunawan [27] that project learning strategy can improve students' creative thinking skills. Project learning also helps in equipping students to explore innovative capabilities needed in the future [28]. In essence, creative individuals will maintain the originality of the ideas produced [29].

In cognitive psychology, learners in higher education include the adult category or at the post-formal reasoning stage [30]. This is characterized by dialectical thinking. Dialectical abilities include understanding, analyzing and finding solutions based on ideas, theories, opinions, and contradictory thoughts that are capable of being synthesized into new and creative thoughts [25]. The level ofcognitive maturity depends on how to process information, improve memory and memory capacity, and organize knowledge to solve various problems [26]. These skills are very important specially to support each learning process. Therefore, choosing a unique learning strategy as PBL [31, 32] is very important in facilitating creative thinking skills such as learning project briefs. Finally, choosing the right strategy is required to motivate low-ability students.

4. CONCLUSION

The selection of appropriate learning strategies contributes positively to the creative thinking skills of low-ability physics teacher candidates. Project briefs are learned-centered proven to be better in improving students' creative thinking abilities than conventional learning. The project brief gives a pleasant learning atmosphere so that students become active in completing complex physics concepts. In the future, this study is expected to be a reference for choosing active learning strategies especially for physics students.

ACKNOWLEDGEMENTS

This research was supported by the Ministry of Finance and Research and Technology of Higher Education through the BUDI DN scholarship program.

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