



THE EFFECTIVENESS OF CREATIVE PROBLEM SOLVING-FLIPPED CLASSROOM FOR ENHANCING STUDENTS' CREATIVE THINKING SKILLS IN ONLINE PHYSICS EDUCATIONAL LEARNING

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ABSTRACT

Physics science differs from other educational programs. As a natural science subject, this study program has many mathematical formulas, complex scientific laws, theorems, and scientific postulates. This study program needs creative thinking skills since physics learning is related to creativity in solving scientific problems. CPS (Creative Problem Solving) and flipped classrooms are some efforts to increase creative thinking skills. In Indonesia, COVID-19 is the main reason for conducting online learning. However, there is no supporting information about the effectiveness of CPS and flipped classrooms as methods for online physics learning in university. Thus, this study aims to identify the effectiveness of CPS-flipped classrooms assisted by videos in enhancing university students' creative thinking skills for online learning. The study participants were university students from the Physics Education Study Program (population = 66 students, random cluster sampling for the sampling method) of Mataram University. They were divided into the control and experimental or treatment groups. This study used a pre-test and post-test group design (seven description questions). All questions were validated and reliable. All data were analyzed using an N-gain score and t-test. The results show that the N-gain score is in the medium zone. The data were normally and homogeneously distributed. The analysis result using the t-test shows that the addition of flipped classrooms is more effective than the control group (CPS only). CPS-flipped classroom performs better than CPS, proving the ability of flipped classrooms as the alternative method in online learning.

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Keywords: creative thinking skill; effectiveness; flipped classroom; learning strategy

INTRODUCTION

Physics is one of the most fundamental science with many differences from the other educational study program or sciences regarding complexity. Since it is related to the natural science subject, this study program has many mathematical formulas, complex scientific laws (Elyyan et al., 2016; Roche et al., 2016; Puspitasari et al., 2021), theorems, and scientific postulates (Vinitsky-Pinsky & Galili, 2014; Del Barco et al., 2022; Fielding et al., 2022).

According to previous studies, physics learning in higher education has a significant relationship with conceptual understanding, reasoning power, physical method and technique skills, and self-study (Elayyan et al., 2016; Puspitasari et al., 2021). Most university students find physics subjects difficult and challenging to solve given problems, especially not routine problems. Students feel confused about some questions. These difficulties may be related to the learning strategy used monotonously. Somehow, the lecturer dominated learning activities, giving modules, exercises, or discussions that were not structured. It needs a specific learning method – a learning stra-

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tegy that helps students get the proper outcomes. A prior study showed that using innovative learning media enhances students' abilities. This study simulated the increasing level of students in the theories understanding using learning media (Krobthong, 2015). However, this research only identifies general academic achievement.

As physics is well-known to be a complex science that is hard to study, there should be an innovative way to enhance students' interest in learning physics (Limatahu & Mubarok, 2020). There is a strong relationship between learning interest and the students' outcomes. Many previous studies confirm the correlation between learning interests and learning outcomes (Tsai et al., 2021; Asikainen et al., 2022; Schweder & Raufelder, 2022; Tuzlukaya et al., 2022). In line with this, it is urgently required to identify and develop a novel learning model – a learning strategy that makes it easier for students to learn physics.

The students are prospective teachers who will also have to educate their students. Students will also have to teach their prospective students about social life. Hence, students' skills in problem-solving need to be developed. The development focuses on generating students with good competency and quality, including their attitude and interest in the lessons (Ernawati et al., 2022). Many innovations in learning strategy can increase problem-solving skills and are related to the students' creative thinking. CPS (creative problem solving) may change how university students create their study paths and structure their education (Chanayotha & Na-Songkhla, 2015; Rubenstein et al., 2019). Instead of specializing in specific occupational tasks, the students are encouraged to study more general, multidisciplinary subjects as part of their qualifications (Kashefi et al., 2012; Chen et al., 2021). As one of the innovative learning strategies, CPS is a learning strategy that can measure students' creativity (Sophonhiranraka et al., 2015; Rubenstein et al., 2019).

Determining the potential sources of variability in the CPS method may become a point of interest (Chanayotha & Na-Songkhla, 2015; Stolz et al., 2022). CPS learning strategy is suitable for problem-solving due to its application in concentrating problem-solving skills and skill strengthening (Beda et al., 2020; Hooijdonk et al., 2022). In this strategy, when a student is faced with a question, he can bring out his ability in problem-solving by choosing or developing his response (Kashefi et al., 2012). Not only by memorizing without thinking but also by solving the problem and expanding the thinking process (Sophonhiranraka et al., 2015; Hooijdonk et al., 2022). In

some cases, CPS is related to an entrepreneurship curriculum due to its application in the entrepreneurial process (Stolz et al., 2022).

A flipped classroom is a simple inverted classroom with two defining components: moving the lecture outside of class, usually delivered through electronic means, and moving the practical application assignments, formerly homework, into the classroom (Forster et al., 2022; Nja et al., 2022). Many other optional components arguably optimize this structure and provide enhanced learning opportunities to students, creating a wide variation in practice (Elzainy & El Sadik, 2022; Widodo, 2022). The lecture format has varied and evolved from audio, screen captures, presentation slides, podcasts, narrated presentations (Turiman et al., 2012; Tinmaz et al., 2022; Senali et al., 2022), video, and other multimedia content (Forster et al., 2022; Phillips & Wiesbauer, 2022).

The flipped classroom has some differences from other models regarding the component variations. In other words, the classroom component is also varied, with different learning expectations, engagement techniques, levels of student autonomy, and other variabilities (Wang et al., 2022; Youhasan et al., 2022). Lecturers have taken countless paths to teaching with the flip because the learning context and objectives determine the most useful features. However, the new era after the COVID-19 pandemic demands a new learning strategy that can adopt an online or blended learning system, as studied in a previous study for university students (Widodo, 2022), especially for the physics educational study program, which has a specific science. This study program should apply an innovative learning strategy to enhance students' learning outcomes for this new era (online learning management system). The COVID-19 pandemic era demands many countries (including Indonesia) to conduct blended learning (a combination of online and offline learning systems using many schematics).

Many studies confirmed the effectiveness of CPS and flipped classrooms in enhancing learning outcomes. The biggest problem is the limited information about their effectiveness in the new learning era and the combination of CPS and flipped classrooms. There is also limited information about their performance in enhancing creative thinking skills for online and blended learning. There is a need to investigate the effectiveness of CPS-flipped classrooms in enhancing students' creative thinking skills, especially for online physics learning, since online learning has more complex requirements than offline learning systems. In line with this, this study aims to in-

investigate the effectiveness of CPS-flipped classrooms in enhancing university students' creative thinking skills in online physics learning.

METHODS

This study was conducted from September – November 2021 (the school year 2021/2022). The study participants were university students from the Physics Education Study Program (n = 44 students, population = 66 students) of Mata-ran University. They were selected using random cluster sampling. The rationale for selecting this study program was the need to research the effectiveness of the learning strategy. All participants were divided into control (CT, n = 21) and treatment groups (TG, n = 23). The control classroom participants got the CPS, while the treatment group had the CPS-flipped classroom. The difference between the control and treatment groups was the use of the flipped classroom. The participants from the treatment group had learning videos that could be accessed before the learning process in class.

All participants were asked to do the questions for the pre-test (seven description questions) and post-test (Vinitsky-Pinsky & Galili, 2014; Tsai et al., 2021; Elzainy & El Sadik, 2022). A blind expert validated all questions for single questionnaires' content validity and reliability using a Person's correlation coefficient (r) or Pearson's product-moment correlation coefficient. A Cronbach's alpha coefficient (α) was used to measure the internal consistency reliability of the instrument, where a value of >0.05 is determined as reliable (Table 1).

Table 1. Reliability Statistics

Cronbach's Alpha	N of Items
.815	7

The indicators used for the creative thinking skill indicators level are fluency, flexibility, originality, and elaboration. The tests measured the students' initial skills before and after the learning treatment. The results were tested using the normality test (Shapiro-Wilk) and the homogeneity test (Levene's). Then, the effectiveness testing was calculated as the N-gain. According to Hake (1998), the normalized gain index (g) is obtained from the average post-test (S_f) minus the

pre-test average (S_i) divided by the maximum value (S) minus the pre-test average (S_i):

$$(g) = \frac{S_f - S_i}{S - S_i}$$

The interpretation of the N-gain index is shown in Table 2-3.

Table 2. The Value of the N-Gain Index and Its Classification (Hake, 1998)

N-Gain Index	Classification
$(g) \geq 0.70$	High
$0.30 \leq (g) < 0.70$	Medium
$(g) < 0.30$	Low

Then, the data were analyzed using a t -test. All statistical analyses used SPSS software. The *Sig.* value > 0.05 was determined as normally and homogeneously distributed (Ernawati et al., 2022).

Table 3. The Effectiveness Interpretation of the N-Gain Index (Hake, 1998)

N-Gain Index	Classification
<40	ineffective
40 - 55	less effective
56 - 75	effective enough
>76	effective

RESULTS AND DISCUSSION

The pre-test result shows that all students in two groups joined the pre-test session by completing all tasks. As a result, the TG group (female = 20 students, male = 3 students) scored 50-75, with a mean value of 61.22. Another group, the CT group (female = 16 students, male = 5 students), got a mean score of 53.48, ranging from 36-71. According to these results, there is no significant difference between the CT and TG groups since the difference between them is $< 13\%$. All data were homogeneously distributed (*Sig.* value > 0.05). Generally, these two groups had fewer students with a score of > 70 (2 – 3 students). The TG group had eight students with a score of ≤ 50 , while the TG group was better than CT, with only two students. It can be seen that the TG group is better than CG in terms of the initial scores. Table 4 shows the normality and homogeneity test from the pre-test section.

Table 4. Normality and Homogeneity Test from Pre-Test

Test of Normality							
KBKre	Group	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	TG	.099	23	.200	.958	23	.430
	CT	.164	21	.146	.955	21	.415
Test of Homogeneity							
KBKre							
Levene Statistic		df1		df2			Sig.
(TG) 3.363		1		44			.073
(CT) 3.023		1		40			.090

In the post-test results, this study shows that the TG group's experimental class performed better after being treated by the CPS-flipped classroom. The treatment influenced the final score ranging from 64 to 86. The mean value is better than before, resulting in 77.74, which is ~29%

higher than before being treated (61.22). It can be seen that the CPS-flipped classroom shows the success of this method in learning. Table 5 shows the normality and homogeneity test from the post-test section under the participants.

Table 5. Normality and Homogeneity Test from Post-Test

Test of Normality							
KBKre	Group	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
	TG	.159	23	.138	.965	23	.566
	CT	.169	21	.119	.934	21	.164
Test of Homogeneity							
KBKre							
Levene Statistic		df1		df2			Sig.
(TG) 3.363		1		44			.073
(CT) 3.023		1		40			.090

A similar performance was seen in the CT group, with a mean value of 71.14, ranging from 64 to 82. However, the performance in the CT group is still lower than in the TG group, indicating that CPS is not too effective in enhancing

learning outcomes. Besides, the addition of the flipped classroom enhances the learning outcome better than the CPS. For example, in the post-test section of CT, the data interval 60-69 and 70-79 are the dominant areas with 20 students.

Table 6. *t*-Test Result

	Group	N	Mean	Std. Deviation	Statistic
Value	TG	23	78.43	6.178	1.288
	CT	23	71.14	4.871	1.063

The addition of flipped classrooms shifts the data distribution in the TG group, resulting in 21 students from 70-79 and 80-89 data intervals.

Compared to the pre-test results, the dominant areas 50-59 (CT) and 60-69 (TG) data intervals are lower than the post-test results (see Table 6-7).

Table 7. Frequency Distribution of the Learning Outcomes

Interval	Code	Frequency of University Students			
		Pre-Test		Post-Test	
		CT	TG	CT	TG
30-39	Zone 1	3	0	0	0
40-49	Zone 2	3	0	0	0
50-59	Zone 3	10	8	0	0
60-69	Zone 4	3	12	9	2
70-79	Zone 5	2	3	11	12
80-89	Zone 6	0	0	1	9
90-100	Zone 7	0	0	0	0
	Σf	21	23	21	23

The N-Gain index of the CT group has a value of 0.464. This control group (CPS only) has a value of 46.4% or is classified as "medium." For the TG group, the index is 0.605. This index is categorized as a medium result. In other words, the study has an effectiveness of 60.5%. This result confirms that the CPS-flipped classroom is better (effective enough) than the CPS-only group in enhancing the creative thinking skill of the participants. The results are also supported by the t-test result from the post-test (Table 6). The result shows that the coefficient value from the t-test is <0.05 (0.00). This value confirms a significant difference between the CPS-only group and those treated in a CPS-flipped classroom.

The result suggests the use of the CPS-flipped classroom for online learning. As confirmed in many information sources, In Indonesia, the COVID-19 case is the main reason and problem for applying a new learning model. Many schools and universities cannot carry out a face-to-face learning system (normal learning using problem-based learning) for some reasons concerning health mitigation. As an impact, online learning has been applied. However, online learning faces a serious problem that makes many stakeholders think further. As an alternative, a flipped classroom method has been tried (by video, assignment, and many others) (Youhasan et al., 2022).

As confirmed by the initial test results (pre-test), there is no significant difference between groups. During the initial process, all classrooms have a similar outcome, which can be categorized as "Zone 1 - Zone 4". As per the frequency distribution in the pre-test section, the difference between them is only one student. This result indicates a little problem with the current learning model that might influence the students' ability (it can be seen in the initial test result that the

scores are not maximum). From the preliminary stage, the pre-test, it was found that many students at the pre-test section had many difficulties understanding the questions. It can be assumed that many students have low creativity in finding the most straightforward way for the pre-test solutions. These trendlines might be related to the different perceptions of students. As stated in a previous study, the existence of students' perceptions before the COVID-19 learning patterns might become the main problem (Matric, 2018; Chen et al., 2022; Elledge et al., 2022). The students' perception is related to self-regulation, an internal factor that can empower and enhance their learning motivation or independence (Matric, 2018; Šteh & Šarić, 2020; Syefrinando et al., 2022).

Then, the result assumes that creative problem-solving or CPS learning strategy influences learning outcomes even though the process was conducted online (as seen in TG - CT classrooms). The CPS indeed focuses on problem-solving skills through systematic techniques in organizing creative ideas (Beda et al., 2020). Students are not only taught how to memorize without thinking but are required to choose and develop a response to expand the thinking process (Rubenstein et al., 2019). However, a better and more effective model should be applied to increase learning outcomes when online learning has to be applied. In other words, there is still a lack of learning outcome enhancement when it comes to online learning due to many factors.

Then, CPS was combined with the flipped classroom. As found in the TG group, the post-test results show that TG has lesser students in Zone 4 (2 students) than CT (9 students). In this case, the CPS-flipped classroom performed better in enhancing learning outcomes. The flexibility

and fluency of the students are significantly enhanced in the TG group. The students easily explained the answers faster, with a quicker response. In terms of flexibility, they had many sights, different ways, or solutions to the question.

Furthermore, using the CPS learning strategy to answer the questions helps students solve problems using systematic techniques and organize creative ideas (Stolz et al., 2022). Students can choose and develop their ideas and thoughts through creative problem-solving learning models (Rubenstein et al., 2019). The emergence of creative solutions as problem-solving efforts will foster self-confidence, courage to express opinions, divergent thinking, and flexibility in problem-solving efforts (Carmeli et al., 2021; Hooijdonk et al., 2022; Stolz et al., 2022). Creative problem-solving can then interpret students' performance through knowledge creation (Carmeli et al., 2021).

As mentioned and interpreted in the resulting data, the flipped classroom has the potential to enhance learning outcomes. It has a better result than the control group (CPS only). As interpreted in the data, the flipped classroom enhances the students' creative thinking skills. The scores in the control group range from 64 to 82, while the CPS-flipped classroom has a score of 64 to 88. The potency of CPS as a learning strategy can be developed by integrating the flipped classroom to help students understand the learning material (Kanchanachaya & Shinasharkey, 2015; Fauzi, 2022). Applying this learning strategy helps students follow and understand the material step by step before teaching. Firstly, the teacher gave students an assignment to study the material in the learning media. This learning strategy made students required to be more independent because they studied the material before the online meeting. This strategy also made students more active because their curiosity increased (Youhasan et al., 2022).

From the students' perspectives, this strategy was suitable in line with the development of science and technology in Industrial Era 4.0. Consequently, this change in the learning model required training and readiness of students to prepare the compatible learning media with current technological developments. Teachers can easily download materials that students will learn from the available learning management systems. Then, the material is sent to students with instructions and will be discussed at the next meeting. When the learning begins, the teacher only needs to discuss with the students by presenting the material. Students can repeat the learning video or access

the learning media every day. Thus, students can use this model to practice their communication skills, as the flipped classroom relates to the students' attitudes (Ruiz-Jimenez et al., 2022).

The teacher became the facilitator, gave a supporting or motivating speech, and observed students' activity (Chanayotha & Na-Songkhla, 2015). Using a CPS with a flipped classroom is suitable for the digital era when learning becomes online. The students do not need to come to the university every day for the learning process. It does not mean that the learning quality decreases, but this is a good alternative learning model for the online era, as happens today (COVID-19 pandemic). This model can be blended learning by the university as an integrated pattern to optimize learning time and time management (Fauzi, 2022). In the aspect of students' attitudes and flipped classroom relationship, as supported in a previous study, the flipped classroom's impact on learning is based on its capacity to stimulate students to do things to learn and become more involved in their learning (Prieto et al., 2021). Similarly, the flipped classroom allows students to work in technological environments (Ruiz-Jimenez et al., 2022). Therefore, this study's results are consistent with Flores et al. (2016), who pointed out that flipped classrooms make students show positive attitudes toward their subjects.

CONCLUSION

According to the study results, flipped classrooms make students show a positive attitude toward their study subjects. The CPS-flipped classroom group has better learning outcomes than the CPS-only group. The CPS-flipped classroom combination is a good alternative learning strategy for the online era, as happens today (COVID-19 pandemic). Flipped classrooms can enhance the creative thinking skills for online physics educational learning. As a recommendation, this learning strategy can be applied as blended learning by the university in an integrated pattern to optimize learning time and time management for online learning.

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