ISSN : 2549-2764 (ONLINE)
ISSN : 2337-604X (PRINT)

BERKALA ILMIAH PENDIDIKAN FISIKA

https://ppjp.ulm.ac.id/journal/index.php/bipf

The Effect of Creative Problem-Solving Model to Enhance Scientific Creativity: Study in Static Fluid Physics Learning

Shinta Dewi, Iwan Permana Suwarna*, and Ahmad Suryadi
Physics Education, Faculty of Pedagogy and Education Sciences
UIN Syarif Hidayatullah, Jakarta, Indonesia
*iwan.permana.suwarna@uinjkt.ac.id

DOI:10.20527/bipf.v12i1.17668

Received: 18 October 2023 Accepted: 29 December 2023 Published: 1 February 2024

Abstract

The purpose of this study is to ascertain how applying the Creative Problem-Solving model in physics classes affects students' scientific creativity when studying static fluids and how applying the model can improve students' scientific creativity. This study employed a quasi-experimental method, with the population of focus being 11th-grade science students at SMAN 4 South Tangerang, totaling 200 students. The sample in this study involves 78 students selected through the purposive sampling technique and divided into two groups (experimental and control), each comprising 39 students. Both groups were assessed for their skills through pretests and post-tests. The instruments used in this research consisted of 5 structured essay questions referring to three indicators of scientific creativity dimensions developed by Hu and Adey. The result of this study shows that the data generated, based on the Mann-Whitney U test, indicates a significant difference between the post-test scores of the two groups, with a Sig. Value of 0.000, which is below 0.05. The N-gain results also showed a gain of 0.56 in the experimental group and 0.43 in the control group. In conclusion, the Creative Problem-Solving model influenced students' scientific creativity, and it effectively improved students' scientific creativity. The research implications suggest that teachers should implement this teaching method to improve students' scientific creativity skills, enabling them to actively and skillfully address various complex problems in everyday life.

Keywords: Creative problem solving; Scientific creativity; Static fluid

How to cite: Dewi, S., Suwarna, I. P., & Suryadi, A. (2024). The effect of creative problem-solving model to enhance scientific creativity: Study in Static Fluid Physics Learning. *Berkala Ilmiah Pendidikan Fisika*, 12(1), 21-35.

INTRODUCTION

The developments of the 21st century, starting from the Fourth Industrial Revolution to Society 5.0, demand increasingly competitive skills to confront various life challenges, including cultivating creativity. Creativity is important across many disciplines, including science (Cerisola, 2018; Charyton et al., 2015; Mukhambetalina & Dalbergenova, 2022; Saregar et al., 2021; Suyidno et al., 2019). In this context, "scientific creativity" refers to the ability to think creatively in scientific experiments, discover scientific problems, and solve problems in scientific activities (Haryandi et al., 2021; Hu & Adey, 2002; Setyadin et al., 2019; Sidek et al., 2020). Students who are consistently trained to think scientifically and creatively have been shown to have a better grasp of learning concepts and enhance their' problem-solving skills (Haim & Aschauer, 2022; Li et al., 2022). This is because optimal scientific creative thinking skills can unlock potential in physics learning, such as students' ability to identify complex problems, seek creative solutions, and develop a deep understanding of physics concepts. Furthermore, scientific creative thinking skills can also enhance students' creativity in formulating new questions, connecting different concepts, and conducting innovative scientific experiments.

The enhancement of students' scientific creativity is of paramount importance (Muhammad et al., 2023; Rizqi et al., 2019). Previous research indicates that the scientific and creative thinking skills of students in Indonesia are still relatively low (Astutik et al., 2020; Fadllan et al., 2019; Mustika et al., 2019). One of the indicators is that approximately 64% of students score within the 0-60 range in scientific and creative thinking (Lailiyah & Suliyanah, 2018). Therefore, there is an urgent need to improve these skills, particularly in the context of physics education, which often involves complex and abstract concepts.

To address this issue, this research will focus on implementing the Creative Problem-Solving (CPS) model to enhance students' scientific creative thinking skills. This model has been proven effective in increasing students' curiosity, interest, and achievement in previous studies (Fahrisa, 2022; Thayyib, 2019). Furthermore, CPS is also considered to assist students in developing problem-solving skills and understanding physics concepts (Saputra et al., 2021; Satriani & Wahyuddin, 2019).

Several studies have examined how the Creative Problem-Solving approach impacts students' scientific creativity. For example, Fatimah (2019) used the Creative Problem-Solving paradigm to evaluate the impacts of worksheets with scaffolding. She discovered that, compared to the control group, students in the experimental group's scientific creativity significantly improved. Furthermore, Pratiwi (2018) showed how using the creative problem-solving paradigm to teach students might improve their conceptual understanding and scientific creativity. Although previous studies by Fatimah et al. (2019) and Pratiwi et al. (2018) have shown the influence of the Creative Problem-Solving model on scientific creativity, they measured scientific creativity using a set of seven items created by Hu & Adey (2002) as a whole, without distinguishing between the three dimensions of product, trait, and process. In their research, Hu & Adey (2002) are known to have developed scientific creativity skills divided into three dimensions, as seen in Figure 1. However, separating the dimensions of product, trait, and process in assessing students' scientific creativity can provide a clearer evaluation. Furthermore, exploring scientific creativity in specific domains like physics remains limited (Fadllan et al., 2022; Rif 'at et al., 2020). Scientific creativity cannot be separated from the scientific concepts students are learning, including physics (Oh, 2022). In other words, it can be concluded that the knowledge of physics concepts is related to students' scientific creativity.

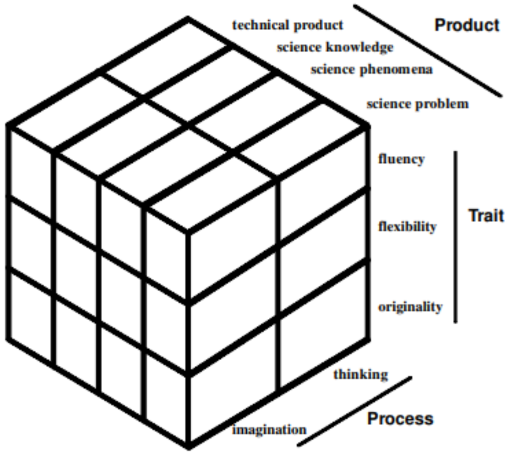

Figure 1 Scientific Structure Creativity Model (SCCM) (Hu & Adey, 2002)

The researchers have not found any studies discussing the relationship between the Creative Problem-Solving model and each indicator of the dimensions. However, because the topic in this research pertains to static fluid materials with concepts related to daily life, only the thinking element is used without including the imagination element in the dimension's process indicator. The difference in this research compared to previous studies lies in the stages of the Creative Problem-Solving model used. The researchers employed the Creative Problem-Solving model, developed by the Creative Education Foundation, which consists of four stages: clarify (problem clarification), ideate (exploring ideas), develop (developing ideas into solutions), and implement (implementation) (Creative Education Foundation, 2015).

This research aims to measure the influence of using the Creative Problem-Solving learning model in enhancing the scientific creativity skills of high school students when studying static fluid materials in physics lessons. The measurement of scientific creativity skills is conducted using a test designed based on the indicators of scientific creativity (Hu & Adey, 2002). This research is expected to provide valuable information and considerations for physics educators when implementing the Creative Problem-Solving learning model to develop students' scientific creativity skills.

METODOLOGY

This research is a quasi-experimental study designed to examine the influence of the Creative Problem-Solving model in enhancing students' scientific creativity. The research design used is the Nonequivalent Control Group Design. The structure of the research design is explained in Table 1.

Table 1 Research design structure

Group	Pretest	Treatment	Post-test
Experimental	O_1	X	O_2
Control	O_3	-	O_4

(Creswell & Creswell, 2018)

This research was conducted in one of the public high schools in South Tangerang City. This study involved 78 students, including 28 male students and 50 female students from classes XI IPA 1 and XI IPA 4, selected using a purposive sampling technique. Class XI IPA 1 was designated the control group with conventional learning methods, while class XI IPA 4 was the experimental group using the Creative Problem-Solving model.

Each group underwent five meetings with a focus on static fluid physics material. Pretest data was collected during the first meeting. Subsequent meetings (second, third, and fourth) were part of the static fluid learning process, covering subtopics such as hydrostatic pressure, Pascal's law, Archimedes' principle, surface tension, capillarity, and viscosity. In these three meetings, the experimental group received treatment using the

Creative Problem-Solving model, while the control group received treatment using the conventional model. In the fifth meeting, post-test data collection was conducted to assess students' final scientific creative thinking skills after the intervention or different treatments in both groups.

The instrument used refers to three indicators of scientific creativity dimensions according to Hu & Adey (2002), which are indicators of the product dimension consisting of science phenomena, science knowledge, science problems, and technical products; indicators of the process dimension consisting of thinking; and indicators of the trait dimension consisting of fluency, originality, and flexibility (Hu & Adey, 2002). The instrument used to measure scientific creativity skills is a written test that has been validated by six experts and has undergone a series of psychometric tests with a validity correlation of 99% and a reliability of 0.878. This test consists of problems such as problem identification, idea generation, and solution evaluation.

This research employed data collection through pretests and post-tests. The pretest was administered before the intervention to measure the initial scientific creativity skills of the students. At the same time, the post-test was conducted after the intervention to assess changes in the students' scientific creativity skills.

The data obtained will be analyzed using descriptive and inferential statistics. Changes in scientific creativity skills will be measured through observations of the pretest and post-test median scores and based on the N-gain calculation. The analysis refers to the N-gain criteria found in Table 2.

Table 2 N-gain category

N-gain Values	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Moderate
$g < 0.3$	Low

(Hake, 1999)

The N-gain data analysis was conducted to assess the improvement in students' creativity, while the Mann-Whitney U test was performed to examine the influence of the Creative Problem-Solving model on high school students' scientific creativity. Normality and homogeneity tests were conducted as statistical prerequisite tests before the Mann-Whitney U test. Furthermore, an effect size test was also carried out to measure the magnitude of the strength of the relationship between variables. Effect size measurement can provide additional information that cannot be explained by p-values or the significance levels of hypothesis testing results because it is independent of sample size effects. The effect size analysis refers to the criteria of Pearson's r as outlined in Table 3.

Table 3 Effect size category

r Values	Category
≥ 0.70	Much Larger
0.50	Large
0.30	Medium
0.10	Small

(Morgan et al., 2012).

RESULTS AND DISCUSSION

Improvement in Scientific Creativity Skills through the CPS Model

The influence of the Creative Problem-Solving model on students' scientific creativity skills is measured using pretest and post-test analysis. Figure 2 shows the pretest scores of both groups before the treatment was provided.

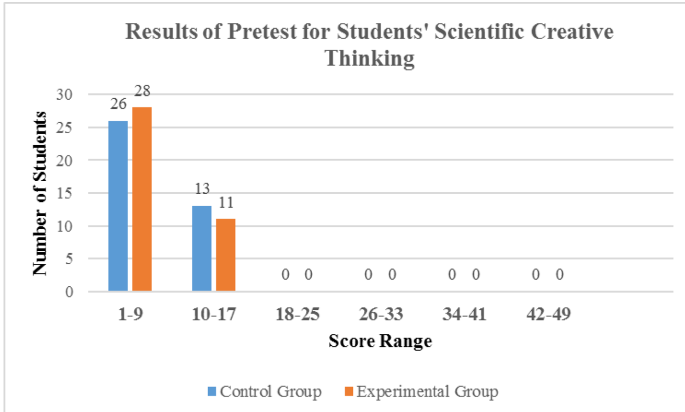

Figure 2 Diagram of the pretest results for students' scientific creative thinking

In Figure 2, the distribution of student scores is observed within the range of score intervals. From the results, it is evident that the scores of both groups fall into the low category, with a score range of 1-17 out of a maximum score of 52. Data analysis reveals that the median score for both groups only reaches 6 out of the ideal score of 52. In general, the analysis indicates no significant difference in scores between the two groups. Thus, it is concluded that the initial skills of both groups are comparable. Information regarding the pretest results of students on the scientific creativity product indicator, according to Hu and Adey (2002), can be found in Table 4.

Table 4 The pretest scores for each dimension indicator

Scientific Creativity Indicators	Control Group		Experimental Group	
	Median	%	Median	%
Product Dimension Indicator				
Science Phenomena	1	21.04%	1	20.83%
Science Knowledge	0	11.04%	0	10.00%
Science Problem	0	12.03%	0	11.25%
Technical Product	0	9.38%	0	8.96%
Trait Dimension Indicator				
Fluency	1	13.96%	1	13.54%
Originality	0	13.13%	0	12.38%
Flexibility	1	13.00%	0	12.38%
Process Dimension Indicator				
Thinking	1	13.37%	1	12.76%

Based on the median and percentage scores for each element of the three dimensions of indicators, it appears that the skills of both groups in each indicator are nearly similar. Both groups demonstrate a high level of proficiency in understanding scientific phenomena compared to other aspects of scientific creativity. However, they exhibit a significantly low level of proficiency in the technical product indicator. The average percentage scores reveal that the control group outperformed the experimental group in the pretest.

Next, information about the post-test data on students' scientific creativity skills after receiving different treatments in the control and experimental groups can be seen in Figure 3.

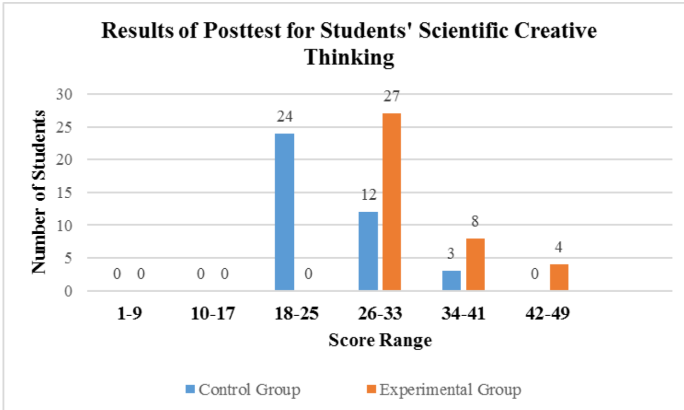

Figure 3 Diagram of the post-test results for students' scientific creative thinking

Figure 3 shows a significant difference in the post-test results between the two groups. The post-test scores for the control group are distributed between 18-41, while the experimental group scores fall within the range of 26-49. Data analysis reveals an increase in the median scores for both groups. The control group experienced a total score increase of 25 from the ideal score of 52. Meanwhile, the experimental group saw a total score increase to 29 from the ideal score of 52. Table 5 presents information on the post-test scores of students in the control and experimental groups related to the three dimensions of scientific creativity indicators, according to Hu & Adey (2002).

Table 5 The post-test scores for each dimension indicator

Scientific Creativity Indicators	**Control Group**		**Experimental Group**	
	Median	**%**	**Median**	**%**
Product Dimension Indicator				
Science Phenomena	2	57.29%	3	68.96%
Science Knowledge	2	51.25%	2	60.42%
Science Problem	2	42.34%	2	54.69%
Technical Product	2	47.92%	2	56.88%
Trait Dimension Indicator				
Fluency	2	57.92%	3	67.50%
Originality	2	46.75%	2	56.75%
Flexibility	2	46.25%	2	58.25%
Process Dimension Indicator				
Thinking	2	49.70%	2	60.23%

The post-test results for both groups show a significant difference in each aspect of the indicators of scientific creative thinking, both in each element of the product dimension and in each element of the trait dimension indicators, particularly in the elements of science phenomena and fluency. The maximum increase occurred in the experimental group. In this study, the science phenomena indicator element was measured by asking students to identify the factors causing the problem and formulate problems related to hydrostatic pressure through the phenomenon of the collapse of the Situ Gintung embankment.

Question: *On March 26, 2009, heavy rainfall led to the rupture of the Situ Gintung embankment, with the breach occurring primarily at the base of the embankment.*

a. *Aside from the swift and forceful water flow on the embankment, explain why heavy rainfall caused the embankment to rupture!*
b. *Besides structural damage and property loss on the embankment, enumerate as many impacts as possible resulting from the rupture of an embankment!*
c. *If allowed to investigate the Situ Gintung embankment, what aspects would be your focus?*

The post-test results reveal that students in the experimental group provided more varied answers than the control group. Figure 4 shows one of the answers to the science phenomena indicator element from each group.

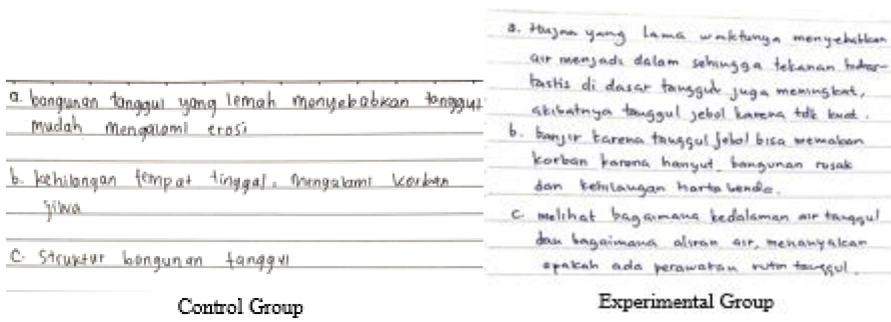

Figure 4 Post-test answer of the control group and experimental group on the elemen of the science phenomena indicator

Items a, b, and c have different assessments regarding students' fluency, flexibility, and originality. Scoring on item (a) or fluency is evaluated based on how smoothly students can explain why heavy rain causes the embankment to break. Scoring on item b or originality is assessed by how many answers students can find related to the impact of a broken embankment. Scoring on item c or flexibility is evaluated by how well students can apply the same concept to different cases. The results of student responses in Figure 4 indicate that students in the experimental group are more fluent in explaining (item a) compared to the control group. Overall, items a, b, and c show that students in the experimental group can provide more varied answers related to the science phenomena indicator element.

Evaluation of the development of students' scientific creative thinking skills is then conducted by analyzing the n-gain values based on the comparison of pretest and post-test results in Table 6.

Table 6 The average n-gain results

Group	***N-gain***	**Explanation**
Control	0.47	Moderate
Experimental	0.56	Moderate

Table 6 provides information about the difference in n-gain values between the two groups. These n-gain values suggest that learning using the Creative Problem-Solving model produces reasonably effective results. This is because the increase in creative thinking skills is greater than in conventional learning. Table 7 displays the improvement in each aspect of the indicators of scientific creative thinking in both groups based on the average n-gain.

Table 7 The average n-gain results for each scientific creative thinking indicator

	Control Group		**Experimental Group**	
Indicator of Product Dimension				
Science Phenomena	0.47	Moderate	0.64	Moderate
Science Knowledge	0.46	Moderate	0.58	Moderate
Science Problem	0.35	Moderate	0.51	Moderate
Technical Product	0.43	Moderate	0.54	Moderate
Indicator of Trait Dimension				
Fluency	0.53	Moderate	0.65	Moderate
Originality	0.40	Moderate	0.54	Moderate
Flexibility	0.39	Moderate	0.54	Moderate
Indicator of Process Dimension				
Thinking	0.47	Moderate	0.56	Moderate

Table 7 displays the average variance in n-gain improvement in each indicator of students' scientific creative thinking between the two groups. These results demonstrate that the experimental group's scientific creative thinking skills developed more than the control group's, although some indicators still suggest less effective progress in the experimental group. Then, using the data from the pretest and post-test for both groups, a normality test is carried out using the Shapiro-Wilk test. Table 8 displays the outcomes of the test.

Table 8 Results of normality test for pretest and post-test data

	Pretest		***Post-test***	
	Control Group	Experimental Group	Control Group	Experimental Group
Sig.	0.005	0.001	0.001	0.000
Shapiro Wilk Test	Sig. < 0.05 = is rejected			
The decision	Non-normality distributed data			

The Shapiro-Wilk normality test establishes that if the significance level is above 0.05, the residual data values follow a normal distribution. If the significance level is below 0.05, the residual data values do not follow a normal distribution. Table 8 indicates that both groups' pretest and post-test data have significance values less than 0.05. Therefore, it can be concluded that the pretest and post-test data for both groups do not follow a normal distribution. Next, a homogeneity test is conducted on both groups' pretest and post-test data. Table 9 displays the outcomes of the ANOVA test.

Table 9 Results of homogeneity test for pretest and post-test data

	Pretest	**Posttest**
Sig.	0.118	0.003
ANOVA test	Sig. ≥ 0.05 = is accepted	Sig. < 0.05 = is rejected
The decision	Homogeneous data	Non-homogeneous data

The homogeneity test states that if the significance level is greater than or equal to 0.05, the data is homogeneous, and H_0 is accepted. H_0 is rejected if the significance level is less than 0.05 because this indicates that the data are not homogeneous. Table 9 shows that the pretest data is homogeneous, while the post-test data is not homogeneous. This occurred because there was a difference in treatment between the two groups after the pretest was conducted, leading to the post-test scores no longer being homogeneous.

To find out if using the Creative Problem-Solving model affects students' scientific creative thinking abilities when studying static fluids, hypothesis testing is done. The Mann-Whitney U test is used for the hypothesis test since the data are not normally distributed. Table 10 displays the findings of the hypothesis testing.

Table 10 Results of hypothesis testing for pretest and post-test data

	Pretest		**Post-test**	
	Control Group	Exp. Group	Control Group	Exp. Group
Mdn	6	6	25	29
IQR	8	6	7,5	9,5
U	759.500		312.500	
Z	-0.010		-4.490	
Sig.	0.992		0.000	
Mann Whitney U test	Sig. $\geq$ 0.05 = H_0 is rejected		Sig. $<$ 0.05 = H_0 is accepted	
The decision	H_0 is rejected		H_0 is accepted	

The Mann-Whitney U test results for the pretest data indicate that the level of scientific creativity in the experimental group ($Mdn = 6$) is not significantly different from the control group ($Mdn = 6$) before different learning treatments are carried out, $U = 736$, $z = -0.246$, $p = 0.806$. However, after different treatments were applied to both groups, the experimental group ($Mdn = 29$) had significantly higher pretest scores compared to the control group ($Mdn = 25$), $U = 300$, $z = -4.614$, $p = 0.000$ (Field, 2018)

The hypothesis testing criteria state that if the significance level is greater than or equal to 0.05, H_0 is rejected. However, if the significance level is less than 0.05, H_0 is accepted. According to Table 10, the post-test data have a significance value below 0.05, while the pretest data have a significance value over 0.05. Thus, it can be said that the Creative Problem-Solving based learning strategy influences students' scientific creative thinking abilities about static fluids. An effect size test was conducted using Pearson's r to strengthen the conclusion. The results of the effect size test can be observed in Table 11.

Table 11 Pearson's r effect size test results

	Post-test
Z	-4.490
$\sqrt{N}$	0.806
r	-0.58
Pearson's r test	$r \geq 0.5$
The decision	Large

The results of the effect size test on post-test data for the experimental and control groups indicate a large negative relationship between the experimental and control variables (r = -0.58).

The measurement of students' scientific creative thinking skills was conducted using a test instrument consisting of 5 structured essay items based on the scientific creative thinking indicators proposed by Hu and Adey. The selection of these indicators as a reference in this study was based on their relevance to science subjects, particularly in physics. The results of the prerequisite test determined that the data distribution was unbalanced; therefore, statistical data analysis was performed by examining median scores. The measurement results from the pretest data established that students' initial scientific creative thinking skills were in a low category, with the median pretest scores for both the control and experimental groups reaching only 6 out of the ideal score of 52. This indicates that both groups' scientific creative thinking skills were still low. Further examination of the median scores for each indicator revealed that students' initial scientific creative thinking skills in the trait, process, and product dimensions were still in the range of 0 to 1 from the ideal score of 4.

This study indicated that the control group slightly outperformed the experimental group. The Creative Problem-Solving model implemented in experimental classes can be considered more effective than conventional learning in fostering scientific creativity. This outcome aligns with Pratiwi's research. Based on the research findings, it appears that habitual engagement in learning activities using the creative problem-solving model provides students with opportunities for discussion, expressing opinions, and building confidence, thereby enhancing students' thinking skills in the experimental group (Pratiwi et al., 2018).

The measurement results from the post-test data revealed an increase in scores for both groups' scientific creative thinking skills, with the experimental group experiencing an increase in median scores above the control group. The highest increase in median scores occurred in the fluency element in the trait dimension and the science phenomena element. These results suggest that students in the experimental group could think fluently and generate ideas related to scientific phenomena that correlate with real-world occurrences. Both groups showed the lowest score increases in the science problem and technical product elements in the product dimension. This may be attributed to the higher difficulty level of the test items in these elements compared to others.

The improvement in scientific creative thinking skills in the experimental and control groups was analyzed using N-gain calculations. The N-gain results revealed a more significant increase in scientific creative thinking skills in the experimental group, especially in the fluency element. This explains that the steps in the creative problem-solving model effectively enhanced students' scientific creative thinking skills in physics. The model required active participation from students, encouraging them to explore their knowledge together in groups, express opinions, solve problems, and implement solution designs for given problems.

These steps foster students' scientific creative thinking in understanding concepts related to scientific phenomena, solving complex problems, and designing appropriate solutions. Previous research has shown that students who are not actively involved and unable to explore their abilities may struggle to improve their creative thinking skills because they only remember concepts without truly understanding them (Malisa et al., 2018). Additionally, the dominance of the teacher's role and the lack of student involvement in the control group were contributing factors to the low pretest and post-test scores on each indicator of students' scientific creative thinking skills (Wicaksono et al., 2017)

The changes in scientific creativity skills in the experimental and control groups were analyzed using N-gain calculations. The results indicated a significant improvement in the experimental group, with an N-gain of 0.56, while the control group showed an N-gain of 0.43. The higher N-gain value in the experimental group suggests that the Creative Problem-Solving model used effectively enhanced students' scientific creativity skills. In conclusion, the control group with conventional learning methods was ineffective in improving students' scientific creativity skills. The variation in N-gain values between the control and experimental groups indicates the positive effect of implementing the Creative Problem-Solving model on improving students' scientific creativity skills.

Even though the improvement in scientific creative thinking skills in both groups falls within the same category, there is an enhancement in students' scientific creative thinking skills in every element indicator of the product dimension. Skills related to scientific phenomena fall into the moderate category, but the experimental group demonstrated higher skills than the control group. This is attributed to the learning process in the experimental group, which is trained to deepen understanding in objectively analyzing natural events or observable occurrences and formulating problems through clarifying activities based on the phenomena observed.

Both groups, however, tend to be capable of answering questions with low difficulty levels. Regarding scientific knowledge skills, the experimental group exhibited higher skills than the control group. The learning process in the experimental group trains students to explore ideas and express opinions on answers derived from problem formulations through ideation activities or expressing opinions. Concerning the science problem indicator, the percentage obtained by the experimental group is proven to be higher than the control group. The learning process in this indicator trains students in the experimental group to develop their knowledge to formulate solutions to previous ideas through developing activities.

Furthermore, in the technical product skills, the average percentage score obtained by the experimental group is also proven to be higher than the control group. This is because students in the experimental group are accustomed to implementing problem-solving solutions into several technical product ideas in the implementation learning steps. The percentage scores in the science problem and technical product elements appear lower because both groups struggle to answer high-difficulty questions.

Before conducting hypothesis testing, a prerequisite examination was carried out on the data from both groups. The homogeneity test findings verified that the variances between the groups were homogeneous, however, the normality test results showed that the data distribution for both groups did not follow a normal distribution. As the data was not normally distributed, the Mann-Whitney U test method was used to test the hypothesis. Based on the testing, the decision is that H_0

is rejected and H_1 is accepted. This implies a difference in the influence of the Creative Problem-Solving model and the conventional model on improving students' scientific creativity skills.

Subsequently, the effect size test results also reveal that Pearson's r interprets the effect size decision, indicating a high difference between the experimental and control variables. Referring to the increased values in each indicator of scientific creative thinking, it can be concluded that the use of the creative problem-solving model significantly impacts the development of students' scientific creative thinking skills.

These findings indicate that implementing the Creative Problem-Solving model effectively enhances students' scientific creativity skills. This result is consistent with previous research that also demonstrated the effectiveness of this model in an educational context (Fahrisa, 2022; Saputra et al., 2021; Satriani & Wahyuddin, 2019; Thayyib, 2019). The syntax within the Creative Problem-Solving model guides students to actively engage in the learning process, facilitating a more straightforward understanding of the material and training students to implement solutions to problems effectively. Applying the Creative Problem-Solving model is also in line with constructivist learning theory, which emphasizes the importance of students' mental processes in learning. Furthermore, these results support previous studies that have shown the effectiveness of this model in other contexts, such as mathematics and social sciences.

The relatively minor improvement in both the experimental and control groups may be due to students in the experimental group not being accustomed to implementing the creative problem-solving model in learning. Therefore, it is expected that applying the creative problem-solving model to broader topics will make students more familiar with the learning model, resulting in higher improvement in their scientific creative thinking skills. Another factor may be the limited time allocation for extensive material; implementing the creative problem-solving model in learning seems rushed. Fatimah's findings reveal that, apart from the learning model used, other factors can influence the improvement of students' scientific creative thinking. These factors include the level of student motivation, the learning environment, and the teacher's role in supporting students' creative thinking in learning (Fatimah et al., 2019).

CONCLUSION

This study demonstrates that implementing the Creative Problem-Solving model significantly enhances students' scientific creativity skills, as evidenced by an increased N-gain value reaching 0.56. The group using the Creative Problem-Solving model showed better results, particularly in the elements of the science phenomena indicator (68.96%) and fluency (67.50%), compared to the group using conventional teaching methods. These results indicate that the Creative Problem-Solving model can be an effective alternative in physics education practice to improve scientific creativity skills. It emphasizes the importance of selecting appropriate teaching methods to enhance specific skills in the context of science education. Although this research has shown positive results, there is still room for further investigation, such as considering other variables that may affect the effectiveness of the Creative Problem-Solving model or testing this model in different educational contexts. Some obstacles and constraints encountered during this research include time limitations and resource constraints. Therefore, these results should be interpreted considering these limitations. The findings of this research have significant implications for physics education, especially in the application of teaching methods that can support the development of scientific creativity skills. Based on these findings, teachers and educators in physics are encouraged to implement the Creative Problem-Solving model as one of the learning strategies to enhance students' scientific creativity skills.

REFERENCES

Astutik, S., Mahardika, I. K., Indrawati, Sudarti, & Supeno. (2020). HOTS student worksheet to identification of scientific creativity skill, critical thinking skill and creative thinking skill in physics learning. *Journal of Physics: Conference Series*, *1465*(1). https://doi.org/10.1088/1742-6596/1465/1/012075

Cerisola, S. (2018). Multiple creative talents and their determinants at the local level. *Journal of Cultural Economics*, *42*(2), 243–269. https://doi.org/10.1007/s10824-017-9299-8

Charyton, C., Clark, T. M., Ferrer, A., Harding, A., Newton, H., Perry, R. J., Francis, J., & Osiniusi, S. (2015). Reflections of our conversation among the cultures in science and art. *Creativity and Innovation Among Science and Art* (hal. 205–215). Springer London. https://doi.org/10.1007/978-1-4471-6624-5_10

Creative Education Foundation. (2015). Educating for creativity - level 1 - resource guide. *Creative Education Foundation*, 74.

Creswell, J. W., & Creswell, J. D. (2018). Research design : Qualitative, quantitative and mixed methods approaches. In *Introducing English Language*. SAGE Publications, Inc. https://doi.org/10.4324/9781315707181-60

Fadllan, A., Hartono, H., Susilo, S., & Saptono, S. (2022). Pengembangan tes kreativitas saintifik fluida statis berbasis scientific creativity structure model. *Prosiding Seminar Nasional Pascasarjana*, 72–78.

Fadllan, A., Hartono, Susilo, & Saptono, S. (2019). Analysis of students' scientific creativity and science process skills at UIN Walisongo Semarang. *Journal of Physics: Conference Series*, *1321*(3). https://doi.org/10.1088/1742-6596/1321/3/032099

Fahrisa, N. (2022). Creative problem-solving (cps) learning to improve ability an strudent ' s critical and creative thinking on science materials. *Journal of Enviromental and Science Education*, *2*(2), 98–105. http://journal.unnes.ac.id/sju/index.php/jese

Fatimah, S. I., Astutik, S., & Supeno. (2019). Pengaruh lks berbantuan scaffolding dalam model creative problem-solving (cps) terhadap kreativitas ilmiah fisika siswa sma. *Jurnal Pembelajaran Fisika*, *8*(3), 187–193.

Field, A. (2018). *Discovering statistic using ibm spss statistic 5th*. SAGE Edge.

Haim, K., & Aschauer, W. (2022). Fostering scientific creativity in the classroom: The concept of flex-based learning. *International Journal of Learning, Teaching and Educational Research*, *21*(3), 196–230. https://doi.org/10.26803/ijlter.21.3.11

Hake, R. R. (1999). *Analyzing*

Change/Gain Scores. Dept of Physcs Indiana University.

Haryandi, S., Suyidno, S., Misbah, M., Dewantara, D., Mahtari, S., & Ibrahim, M. A. (2021). Scientific creativity: A bibliometric review and analysis. *Momentum: Physics Education Journal*, 10-20.

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, *24*(4), 389–403. https://doi.org/10.1080/09500690110098912

Lailiyah, Q., & Suliyanah. (2018). Profil keterampilan berpikir kreatif ilmiah siswa pada materi momentum dan impuls kelas xi sma negeri 1 tarik sidoarjo. *Jurnal Inovasi Pendidikan Fisika*, *07*(01), 47–50.

Li, Z., Cai, X., Kuznetsova, M., & Kurilova, A. (2022). Assessment of scientific thinking and creativity in an electronic educational environment. *International Journal of Science Education*, *44*(3), 463–486. https://doi.org/10.1080/09500693.2022.2032863

Malisa, S., Bakti, I., & Iriani, R. (2018). Model pembelajaran creative problem-solving (cps) untuk meningkatkan hasil belajar dan kemampuan berpikir kreatif siswa. *Vidya Karya*, *33*(1), 1. https://doi.org/10.20527/jvk.v33i1.5388

Morgan, G. A., Leech, N. L., Gloeckner, G. W., & Barrett, K. C. (2012). *IBM SPSS for Introductory Statistics: Use and Interpretation* (Fourth Edi). Taylor & Francis. http://books.google.com/books?id=yhgGfAEACAAJ&pgis=1

Muhammad, N., Taib, S., Misbah, M., & Zulfah, R. (2023). Bibliometric analysis: Development of electronic teaching materials for physics laboratory courses to train scientific creativity of prospective physics teachers. *Kasuari: Physics Education Journal (KPEJ)*, *6*(1), 46-56.

Mukhambetalina, N. B., & Dalbergenova, L. E. (2022). The development of personal creativity as a scientific and practical problem. *Bulletin of Shokan Ualikhanov Kokshetau University. Philological Series*, *2022*(3), 100–108. https://doi.org/10.59102/kufil/2022/iss3pp100-108

Mustika, M., Maknun, J., & Feranie, S. (2019). Case study : analysis of senior high school students scientific creative, critical thinking and its correlation with their scientific reasoning skills on the sound concept. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032057

Oh, J.-Y. (2022). Understanding the scientific creativity based on various perspectives of science. *Axiomathes*, *32*(6), 907–929. https://doi.org/10.1007/s10516-021-09553-8

Pratiwi, Y. D., Lesmono, A. D., & Astutik, S. (2018). Model pembelajaran creative problem-solving (cps) untuk meningkatkan penguasaan konsep dan keterampilan kreativitas ilmiah siswa. *Jurnal Pembelajaran Fisika*, *7*(4), 356–363.

Rif 'at, M. F., Wati, M., & Suyidno, S. (2020). Developing students' responsibility and scientific creativity through creative responsibility based learning in learning physics. *Berkala Ilmiah Pendidikan Fisika*, *8*(1), 12. https://doi.org/10.20527/bipf.v8i1.7879

Rizqi, Prabowo, & Kirana, T. (2019). The importance of scientific creativity for students on science learning. *IOSR Journal of Research & Method in*

Education (IOSR-JRME), *9*(3), 12–15. https://doi.org/10.9790/1959-0903041215

Saputra, H., Mansyur, J., & Supriyatman. (2021). The Effect of the Conceptual Problem Solving (CPS) Approach on Students' the Representation and Problem-Solving Ability in Physics. *Jurnal Pendidikan Fisika Tadulako Online*, *9*(1), 7–14.

Saregar, A., Cahyanti, U. N., Misbah, M., Susilowati, N. E., Anugrah, A., & Muhammad, N. (2021). CORE learning model: Its effectiveness towards students' creative thinking. *International Journal of Evaluation and Research in Education*, *10*(1), 35-41.

Satriani, S., & Wahyuddin, W. (2019). Implementasi Model Pembelajaran Creative Problem-Solving (CPS) Untuk Meningkatkan Kemampuan Pemecahan Masalah Mahasiswa. *Jurnal Derivat: Jurnal Matematika dan Pendidikan Matematika*, *5*(1), 69–81. https://doi.org/10.31316/j.derivat.v5i1.149

Setyadin, A. H., Efendi, R., & Samsudin, A. (2019). Adaptasi instrumen tes kreativitas ilmiah adaptasi instrumen tes kreativitas ilmiah Hu dan Adey sebagai alternatif untuk mengukur kreativitas dalam konteks sains. *Prosiding Seminar Nasional Fisika*, *5*(March), 23–31.

Sidek, R., Halim, L., Buang, N. A., & Mohamad Arsad, N. (2020). Fostering scientific creativity in teaching and learning science in schools: A systematic review. *Jurnal Penelitian dan Pembelajaran IPA*, *6*(1), 13. https://doi.org/10.30870/jppi.v6i1.7149

Suyidno, S., Susilowati, E., Arifuddin, M., Misbah, M., Sunarti, T., & Dwikoranto, D. (2019). Increasing students responsibility and scientific creativity through creative responsibility based learning. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*, *9*(2), 178-188.

Thayyib, S. (2019). Improving of creative thinking and learning outcomes physics through creative problem-solving (cps) approaches. *Edumaspul - Jurnal Pendidikan*, *3*(1), 20–27. https://doi.org/10.33487/edumaspul.v3i1.77

Wicaksono, I., Wasis, & Madlazim. (2017). The effectiveness of virtual science teaching model (VS-TM) to improve student's scientific creativity and concept mastery on senior high school physics subject. *Journal of Baltic Science Education*, *16*(4), 549–561. https://doi.org/10.33225/jbse/17.16.549