

# The Effect of the Creative Problem Solving (CPS) Learning Model on Students' Creative Thinking Skills in Learning about the Effects of Hydrocarbon Combustion

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## ABSTRACT

Students' creative thinking skills in chemistry learning remain relatively low, particularly on the topic of the impacts of hydrocarbon combustion. Therefore, an effective learning model is needed to enhance these skills. This study offers a specific contribution by examining the implementation of the Creative Problem Solving (CPS) learning model in the context of hydrocarbon combustion, a chemistry topic closely related to real-life environmental issues and requiring students to generate original and relevant solutions. This study was conducted to identify the differences in students' creative thinking skills before and after the implementation of the CPS learning model, as well as to examine the extent of improvement following its implementation. The study employed a pre-experimental method using a one-group pretest–posttest design. The participants were 37 students from class XI-2 of SMAN 3 Serang City, selected through purposive sampling. The findings revealed a significant difference in students' creative thinking skills before and after the implementation of the CPS learning model, as indicated by a sig. (2-tailed) value of 0.000 ( $< 0.05$ ). The students' average score increased from 28% to 76%, while the N-gain results showed a moderate to high level of improvement. These results indicate that the CPS learning model was effective in improving students' creative thinking skills and provides empirical support for its use in contextual chemistry learning, particularly on environmental topics such as hydrocarbon combustion.

### Keywords

Creative Problem Solving (CPS), Creative Thinking Ability, Impact of Hydrocarbon Combustion

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## 1. INTRODUCTION

Education is a crucial aspect of human life because it plays an important role in developing students' cognitive potential and creativity. In the era of Society 5.0, learning is expected to be more adaptive to technological advancements and to foster creative thinking skills as one of the essential competencies of the 21st century (Rabia et al., 2024). However, various data indicate that Indonesian students' creative thinking skills still need to be strengthened. The

results of PISA 2022 (OECD, 2023), particularly in the creative thinking domain, show that the average score of Indonesian students was only 19 out of 60, which is lower than the OECD average of 33. Furthermore, only 31% of Indonesian students achieved the baseline level of proficiency in creative thinking, and only 5% were categorized as top performers. Similarly, the Global Innovation Index 2025 ranked Indonesia 55th out of 139 economies, while the country was placed 92nd in the human capital and research pillar. These findings indicate that improving the quality of human resources, particularly in terms of creative thinking skills, remains a significant challenge in Indonesian education.

Creative thinking skills refer to the ability to productively generate, evaluate, and refine ideas in order to produce original and effective solutions to problems (OECD, 2023). In the educational context, these skills are generally measured through four main indicators: fluency, flexibility, originality, and elaboration (Genç et al., 2025; Samaniego et al., 2024). Fluency refers to the ability to generate numerous relevant ideas or responses. Flexibility refers to the ability to propose ideas from different categories or perspectives. Originality refers to the ability to produce unique, uncommon, and unconventional ideas. Elaboration refers to the ability to develop ideas in greater detail, depth, and (Ballerini et al., 2025; Genç et al., 2025).

Hydrocarbons, including the topic of the impacts of their combustion, are chemistry concepts that require understanding at the macroscopic, submicroscopic, and symbolic levels. However, research shows that students' multiple representation skills in hydrocarbon topics remain low, with an overall average of only 29% and submicroscopic-level ability reaching just 35% (Amifelia et al., 2024). In addition, hydrocarbons and petroleum are highly relevant to socio-scientific issues and education for sustainable development; therefore, learning should be designed in a more contextual and meaningful way (Jayanti et al., 2024). In chemistry education, traditional approaches are still considered insufficient to help students develop conceptual understanding and problem-solving skills across the three levels of chemical representation, indicating the need for more innovative and interactive learning strategies (Mujakir et al., 2024). One relevant model is Creative Problem Solving (CPS), which emphasizes problem identification, idea generation, evaluation and selection, and solution implementation. Recent literature reviews have shown that the CPS model is effective in improving students' creative thinking skills (Soraya et al., 2024). Empirical findings also indicate that the implementation of CPS assisted by PhET can improve students' creative thinking skills and cognitive learning outcomes at a moderate level (Yani & Widiyatmoko, 2023). Therefore, the CPS model is considered relevant for teaching the impacts of hydrocarbon combustion in order to help students understand the concepts and develop their creative thinking skills.

According to Osborn, as cited in Munthe & Siva (2023), the Creative Problem Solving (CPS) model consists of six main stages, commonly abbreviated as OFPISA: Objective Finding, in which students discuss the problems introduced by the teacher; Fact Finding, in which students identify relevant facts; Problem Finding, in which students interpret and define the problem; Idea Finding, in which students generate and evaluate possible ideas; Solution Finding, in which students determine the most appropriate solution; and Acceptance Finding, in which students are encouraged to be prepared to address possible subsequent problems.

The implementation of the Creative Problem Solving (CPS) model can be used as an approach to improve students' creative thinking skills in solving chemistry-related

problems, particularly those concerning the impacts of hydrocarbon combustion. This study will be conducted at SMAN 3 Serang City. Based on preliminary observations through interviews with an eleventh-grade chemistry teacher at SMAN 3 Serang City, no previous study has implemented the CPS learning model in this context. As a result, teachers have limited information regarding the level of students' creative thinking skills. Therefore, this study is intended to assist chemistry teachers in identifying students' levels of creative thinking skills in solving problems related to the impacts of hydrocarbon combustion.

Based on the explanation above, this study aims to investigate students' creative thinking skills in solving chemistry problems, particularly on the topic of hydrocarbons, through the implementation of the CPS learning model. Accordingly, the title of this study is: "The Effect of the Creative Problem Solving (CPS) Learning Model on Students' Creative Thinking Skills in Learning about the Effects of Hydrocarbon Combustion."

## 2. METHOD

This study employed a pre-experimental method, which is an experimental research design involving a single group of participants receiving a treatment without a comparison control group (Creswell, 2012). The research design used was a one-group pretest-posttest design, in which a pretest is administered before the treatment, followed by the treatment, and concluded with a posttest administered to the same group in order to examine the effect of the treatment. This design is commonly represented by the notation  $O_1 X O_2$ , where  $O_1$  denotes the pretest,  $X$  denotes the treatment, and  $O_2$  denotes the posttest. In this study, the Creative Problem Solving (CPS) learning model served as the independent variable because it was the treatment manipulated in the experiment, while students' creative thinking skills on the topic of the impacts of hydrocarbon combustion served as the dependent variable because they were the outcomes measured after the treatment was administered.

In this study, participants included 33 students in grades XII-3 as respondents in the empirical validity and reliability tests of the instrument, and 37 students in grades XI-2 of SMAN 3 Serang City as the research sample. The study was conducted at SMAN 3 Serang City, located on Jl. Raya Taktakan, Km 0.5, Taktakan District, Serang City, Banten. This study used a purposive sampling technique, in which the sample was selected based on specific considerations to obtain participants who were considered more representative of the sources and information needed, as explained by Sugiyono (as cited in Lenaini, 2011).

The research instruments consisted of treatment instruments and measurement instruments. The treatment instruments included teaching modules and student worksheets (LKPD), which were intended to facilitate the learning process. The measurement instruments consisted of essay-based pretest and posttest questions designed to identify differences in students' creative thinking skills before and after the implementation of the CPS learning model, observation sheets used to assess the implementation process of the CPS model in relation to students' creative thinking skills, and validation sheets used to determine the feasibility of the research instruments. All research instrument items were subjected to content validation using Aiken's  $V$ . The validation process involved five expert validators who assessed the items using a 5-point Likert scale. Based on the established criterion, all instrument items were considered valid because their Aiken's  $V$  values were equal to or higher than 0.80 (Aiken, 1985; Zulkarnain et al., 2025).

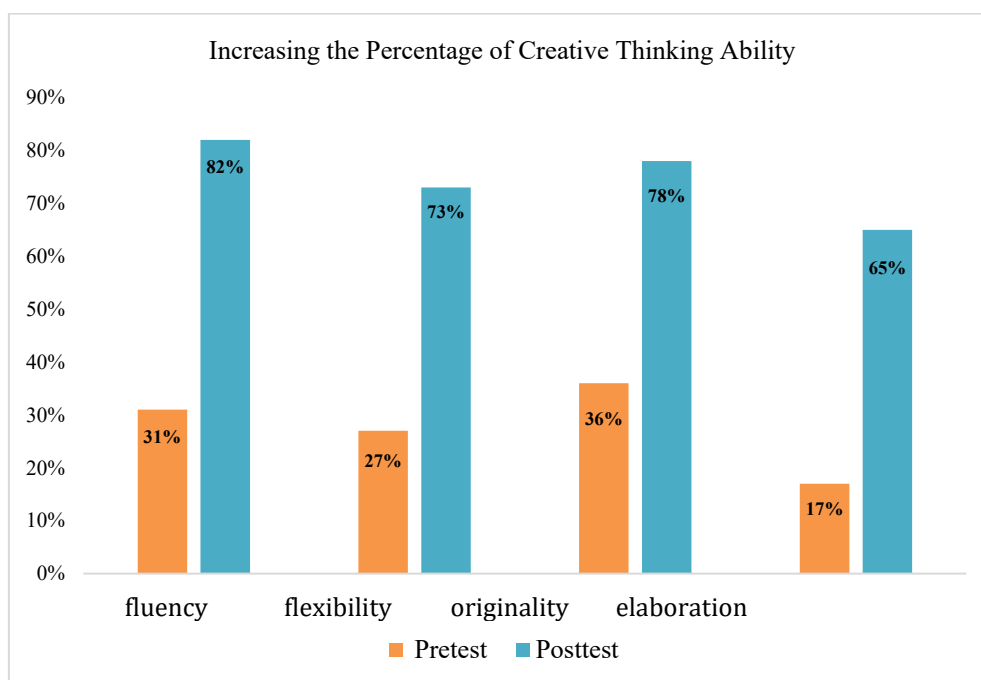
The data were analyzed using the N-gain test, normality test, and hypothesis testing through a paired-samples t-test with the help of SPSS version 26 and Microsoft Excel. The hypotheses of this study were formulated as follows:

- $H_0$  : There is no significant difference in students' creative thinking skills on the topic of the impacts of hydrocarbon combustion before and after the implementation of the CPS learning model
- $H_1$  : There is a significant difference in students' creative thinking skills on the topic of the impacts of hydrocarbon combustion before and after the implementation of the CPS learning model

### 3. RESULT AND DISCUSSION

#### 3.1. Result

In this study, the data for the students' creative thinking ability test on the impact of hydrocarbon combustion material was obtained from pretest and posttest data. The pretest was given before the CPS learning model was implemented to determine the students' initial abilities before learning and the average pretest score was 28. The posttest was given to students after the CPS learning model was implemented to determine whether there was a difference between before and after the CPS learning model was implemented and the average posttest score was 76.



**Figure 1.** Increasing the percentage of creative thinking ability

In addition, a percentage test was conducted on students' pretest and posttest answers for each indicator of creative thinking ability, which shows the percentage of students' achievement scores for creative thinking ability using the CPS learning model on the topic of the impact of hydrocarbon combustion. The results of the study showed an increase in the percentage of students' creative thinking ability for each indicator. The percentage of students' creative thinking ability in the pretest and posttest answers can be seen in Figure 1.

In this study, a normality test was conducted as a prerequisite test aimed at determining whether the distribution of the research data obtained was normal. In the process, this test was conducted using the Shapiro-Wilk test in the SPSS 26.0 application with a probability of 5%. In this test, a research sample of 37 class XI-2 students at SMAN 3 Kota Serang was used, so that decisions were taken based on the Shapiro-Wilk test. The data from the normality test results for the test questions can be seen in Table 1.

**Table 1.** Normality Test Results for the Pretest and Posttest

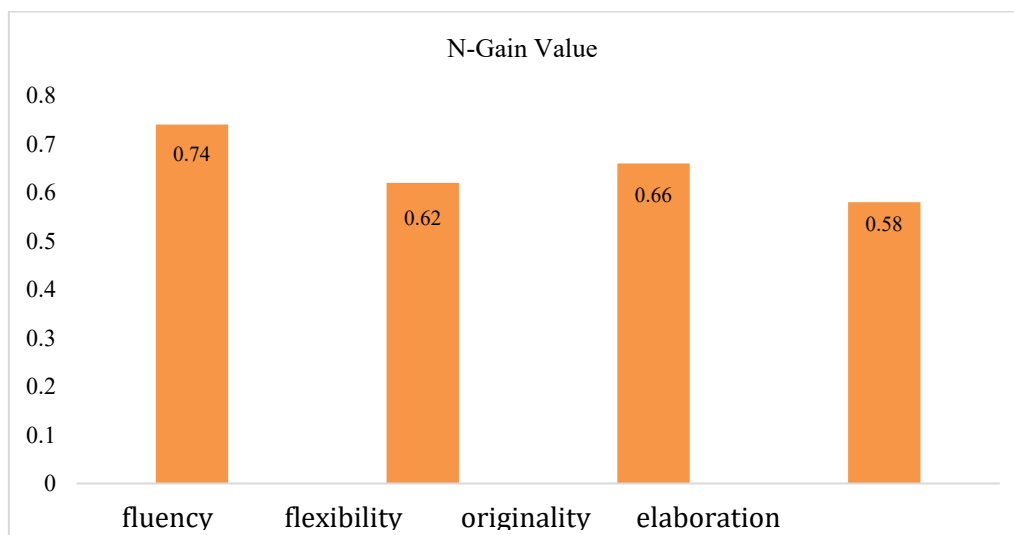
Pretest-Posttest	Statistic	df	Sig.	Information
Pre-Test	0,084	36	0,608	Normal
Post-Test	0,142	36	0,112	Normal

According to Table 1, the significance value for the pretest was 0.608 and the posttest was 0.112. Both values are greater than 0.05, indicating that the research data, both pretest and posttest, were normally distributed. Therefore, a Paired Sample T-Test can be performed.

**Table 2.** Hypothesis Test Results (Paired Sample T-Test)

Data	T	df	Sig.(2-tailed)
Pretest- Posstest	-20.705	35	0,000

Hypothesis testing was conducted after the research data was declared normally distributed. The hypothesis test used was the Paired Sample T-Test in SPSS 26.0 because this study only used one class as a sample. The purpose of the hypothesis test was to provide evidence for the previously formulated problem. The data obtained from the hypothesis validation test for the test questions are shown in Tabel 2.



**Figure 2.** N-Gain Value of Creative Thinking Skills

According to the test results in Table 2, the sig (2-tailed) pretest and posttest values were 0.000 and showed that the significance value was less than 0.05. This is in accordance with the criteria for making a hypothesis decision, namely if the significance value is  $<0.05$ , then  $H_0$  is rejected and  $H_1$  is accepted, so it can be concluded that there is a difference in students' creative thinking abilities between before and after the CPS learning model was applied to the material on the impact of hydrocarbon combustion.

An n-gain test was then conducted on the students' pretest and posttest results. This test was conducted to determine the effectiveness or improvement in students' creative thinking skills on the impact of hydrocarbon combustion after the Creative Problem Solving (CPS) learning model was implemented. There was an increase in each indicator, as seen in the n-gain values obtained, as shown in Figure 2.

### 3.2. Discussion

The paired-sample t-test results showed a significant difference in students' creative thinking skills before and after the implementation of the CPS model, as indicated by the sig. (2-tailed) value of 0.000 ( $< 0.05$ ). This finding indicates that the CPS model contributed meaningfully to the improvement of students' creative thinking skills. Such improvement may be explained by the nature of creative thinking itself, which involves generating, evaluating, and improving ideas to produce original and effective solutions (OECD, 2023). In addition, the topic of the impacts of hydrocarbon combustion provided a contextual learning setting because fossil-fuel combustion is closely related to air pollution and greenhouse gas emissions in everyday life. Context-based chemistry learning has been shown to make chemical concepts more meaningful and relevant to students' lives. Therefore, the use of CPS in this topic likely encouraged students not only to understand chemistry concepts, but also to develop more flexible and original responses to real environmental problems. This result is consistent with previous chemistry learning research showing that creative problem-solving approaches can improve students' understanding and scientific work (Heliawati et al., 2021).

#### a. Fluency Thinking

Fluency thinking is assessed based on how they generate a large number of ideas with a smooth flow of thought. In this study, the fluency indicator increased to the high criterion, with an n-gain score of 0.74. Furthermore, the increase in fluency is also evident in the average pretest score of 31% and the average posttest score of 82%. This is consistent with observations, which show the fluency indicator achieved the highest percentage, at 80%, which falls within the very good criterion.

During the learning activities, students identified and responded to the problems presented at the Objective Finding stage. Based on these findings, fluency was the highest indicator of creative thinking ability. This indicates that students were generally able to generate many relevant ideas and propose more than one possible answer. This finding is in line with recent studies stating that fluency refers to the ability to generate many ideas and that CPS-based learning can improve students' fluency as part of their creative thinking skills (Xia et al., 2025) which showed the results of the fluency thinking indicator with an average of 83.8%, which is classified as very good for students who can express ideas and thoughts fluently and more than one answer, solve problems from different perspectives, resolve situations based on thought, and make changes that impact a problem.

#### b. Flexibility

Flexibility refers to students' ability to generate diverse ideas and shift to different approaches or perspectives in solving problems. In this study, the flexibility indicator improved to a moderate level, as indicated by an N-gain score of 0.62. This improvement was also reflected in the increase from an average pretest score of 27% to an average posttest score of 73%. Consistent with these results, classroom observations showed that

the flexibility indicator reached 74%, which falls into the good category. During the learning activities, students formulated problems related to the issues presented in the Problem Finding stage. This finding is consistent with recent literature defining flexibility as the capacity to generate multiple distinct ideas or approaches. At the same time, the moderate level of improvement may indicate that students have begun to explore alternative strategies but still tend to rely on familiar methods rather than fully developing varied solutions (Jayanti et al., 2024).

#### c. Detailed Thinking (Elaboration)

Elaboration refers to students' ability to develop and expand ideas in greater detail and depth. In this study, the elaboration indicator improved to a moderate level, as shown by an N-gain score of 0.66. This improvement was also reflected in the increase from an average pretest score of 36% to an average posttest score of 78%. Consistent with these results, classroom observations showed that the elaboration indicator reached 76%, which falls into the good category. During the learning activities, students presented and drew conclusions from the posters they had created at the Acceptance Finding stage. Based on several assessment aspects, the students' presentations achieved an average score of 79% for presentation content, including the title, objectives, content, method, and conclusion; 81% for presentation attitude; and 76% for conceptual understanding. This finding is consistent with recent literature stating that elaboration refers to the ability to develop ideas in detail and depth, as well as with recent research showing that CPS-based learning can improve students' creative thinking skills across all indicators, including elaboration (Putri et al., 2025; Rinjani et al., 2026).

#### d. Original Thinking (Originality)

Original thinking is the ability of students to create something new or something that has never existed before. In this study, the original thinking indicator experienced an increase in the moderate criteria, with an n-gain score of 0.58. Furthermore, the increase in original thinking was also evident in the average pretest score of 17% and the average posttest score of 65%. This is in line with observations, which showed that the original thinking indicator achieved the lowest percentage compared to other indicators, at 73%, which falls within the good criteria. During the learning activity, students designed and created a poster related to how to address the impacts of hydrocarbon combustion, which was given in the solution-finding stage. The poster assessment consisted of several assessment aspects, resulting in an average percentage of 83% (requiring the poster to function properly and achieve its intended purpose), 70% for creativity and originality (including the utilization of existing tools and materials, requiring modifications or developments outside of student direction, and an attractive, neat, and well-structured product), and 75% for problem-solving and independence (requiring students to be active and find solutions to obstacles). Therefore, the poster assessment can enhance students' original thinking skills.

Based on these results, originality emerged as the lowest indicator of creative thinking. This indicates that most students were still not fully able to produce original ideas or formulate new concepts independently. A possible reason is that many students tended to rely on imitation when designing their posters, which limited the emergence of novel responses. This finding may reflect the fact that originality is shaped by multiple factors, including students' individual characteristics, task demands, domain-relevant knowledge, and the classroom environment (Lin et al., 2024). Therefore, improvement in originality

may require longer-term scaffolding and more frequent practice in generating independent and unconventional ideas (Putri et al., 2025).

#### 4. CONCLUSION

Based on the results of the study, it can be concluded that there was a significant difference in students' creative thinking skills before and after the implementation of the Creative Problem Solving (CPS) learning model on the topic of the impacts of hydrocarbon combustion. This was reflected in the increase from the average pretest score of 28, categorized as poor, to the average posttest score of 75, categorized as good. The N-gain result of 0.65 further indicated a moderate level of improvement, and the paired-samples t-test showed a significance value of  $0.00 < 0.05$ . These findings suggest that the implementation of the CPS learning model was associated with an improvement in students' creative thinking skills. However, the findings should be interpreted with caution because this study employed a pre-experimental one-group pretest-posttest design without a control group. As a result, the observed improvement may also have been influenced by potential threats to internal validity, such as maturation effects and testing effects, in addition to the intervention itself. Moreover, the study was conducted in only one class, which may limit the generalizability of the findings. Despite these limitations, the results indicate that the CPS learning model has the potential to be used as an alternative instructional approach to promote students' creative thinking skills in chemistry learning, particularly on topics that involve problem-solving and idea generation.

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