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Improving students' creative thinking skills through creative problem solving model based on socio-scientific issues on environmental change

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ABSTRACT

Creative thinking refers to the ability to generate new and innovative ideas and conclusions to solve problems. This ability develops through interactions among students, teachers, and the learning environment. In biology education, creative thinking skills can be enhanced because the subject involves complex concepts that require diverse problem-solving approaches. Improving creative thinking therefore requires structured efforts, this study aims to examine the improvement of students' creative thinking skills through a socio-scientific issue–based Creative Problem Solving (CPS) model on the topic of environmental change. The research employed a quasi-experimental method with a non-equivalent pretest–posttest control group design involving 61 students divided into experimental and control groups. Data were collected using creative thinking tests and observation sheets to assess learning implementation. The independent samples t-test showed a significant improvement in the experimental group. The experimental group also achieved higher learning gains than the control group, with an N-gain score of 0.68. This improvement occurred because students were able to analyze the causes and impacts of environmental change and propose science-based and socially relevant solutions. Therefore, this learning model can serve as an effective alternative in school education, as it promotes energetic student participation.

Keywords: Creative problem solving, creative thinking, socio-scientific issue

INTRODUCTION

The current learning process not only memorization but also focuses on understanding problems and analysis (Sigit et al., 2019). Science continues to evolve, and the learning process will also likely develop (Magdalena et al., 2023). Socio-scientific issues are a learning approach that can be integrated with social–scientific problems in everyday life (Kurniasari & Fauziah, 2022). Meanwhile, the main advantage of the Creative Problem Solving learning model lies in its power to train students to think systematically, act creatively, and develop strong problem-solving skills (Muslikhah & Nuruddin, 2025). Although the integration of Creative Problem Solving and socio-scientific issues in biology learning is still rarely implemented, this strategy has great potential to enhance 21st-century skills, therefore, the integration of Creative Problem Solving and socio-scientific issues is highly relevant given the complex nature of social problems involving science.

Creative thinking is a skill that students must possess to compete effectively in the 21st century (Faisal et al., 2019). According to study carried out by PISA (Programme for International Student Assessment) in 2022, Approximately 31% of Indonesian students achieve the basic level of creative thinking (Level 3), and only 5% attain the highest performance levels (Levels 5/6). Meanwhile, research conducted by Sihaloho et al. (2017) and Qomariyah et al. (2021) found that the use of conventional and non-contextual learning during the learning process causes students to be less creative, therefore the constructivist approach, which emphasizes collaboration between students and teachers as facilitators, is effective in enhancing creative thinking skills.

One alternative solution to the current problem is the Creative Problem Solving model. The Creative Problem Solving (CPS) learning model aims to foster students' creative thinking skills and help them find innovative solutions through a structured process (Azmi, 2024). The CPS model enables students to participate in group discussions, understand and solve problems, answer questions independently, and synthesize opinions (Herlawan & Hadija, 2017). Through the biology learning process, students are forecasted to expand their creative capacity to discover facts and create biological principles through observing problems related to everyday life (Aryanti et al., 2021).

Socio-scientific issues (SSI) aim to enhance students' understanding of the association between science and society (Zeidler et al., 2009). Socio-scientific issue–based biology learning is effective for analyzing local problems and phenomena in Indonesia (Kenari & Subiantoro, 2023). It is hoped that by using SSI contexts in learning, students will be better able to develop creativity related to science and social concepts in everyday life. SSI encourages creative problem-based learning by utilizing everyday social issues to improve students' ability to digest information (Sari et al., 2021).

Creative thinking is a way of identifying problems, formulating hypotheses, and communicating solutions (Yildiz & Yildiz, 2021). However, senior high school students in Indonesia still show low creative thinking skills (Erfana et al., 2023; Sari et al., 2023). Although CPS model is designed to systematically foster creative and innovative thinking (Azmi, 2024), biology learning tends to emphasize procedural activities rather than cognitive processes. Socio-scientific issue–based learning, particularly through discussion, enables students to engage actively and develop their thinking through real-world problems (Ummah & Subiantoro, 2024). Therefore, integrating CPS with socio-scientific issues has strong potential to enhance 21st-century skills, especially creative thinking.

Environmental change is a biology topic with contextual characteristics because it is closely related to everyday life. Students are confronted with biological problems in their surrounding environment and are expected to identify appropriate solutions to address these issues (Azaly & Fitrihidajati, 2021). In biology learning, environmental change topics offer opportunities for students to cultivate creative thinking skills through problem-solving activities related to real life contexts (Khasanah & Purnomo, 2025). Socio-scientific issues address controversial and ill-structured scientific topics, enabling students to engage in discussions on issues such as environmental change. In addition to fostering creative thinking skills, this approach offers meaningful and contextual learning experiences related to real-world problems. The Creative Problem Solving model based on socio-scientific issues implemented in the experimental class consists of six stages based on the Osborn–Parnes CPS model consists of six stages: objective finding, fact finding, problem finding, idea finding, solution finding, and acceptance finding (Treffinger & Isaksen, 2005).

Previous research conducted by Genisa et al. (2023), Kumar et al. (2024), Naim et al. (2025) and Priyanka et al. (2021) found that revious studies have shown that Socio-scientific issues based learning effectively improves scientific literacy, attitudes, environmental awareness, as well as argumentation and decision making skills. However, most studies primarily emphasize literacy and attitudinal outcomes and apply instructional approaches that are not explicitly structured to develop creative thinking skills. In addition, systematic instructional frameworks such as Creative Problem Solving have not been fully integrated within SSI based learning. This study focuses on environmental change content and quantitatively evaluates enhancements in students' creative thinking skills, addressing a gap in the predominantly descriptive and qualitative literature. Through SSI based learning, students are encouraged not simply to

understand scientific concepts, as well as to develop creative solutions to real world environmental problems.

METHOD

This study used a quasi-experimental design with a Non-Equivalent pretest-posttest control group research design. Different instructional treatments were applied to the experimental and control classes, as shown in Table 1.

Table 1. Research design

Group	Pre-test	Treatment	Post-test
Experimental Class	O_1	X_1	O_2
Control Class	O_1	X_2	O_2

Note : O_1 = Pre-test before treatment
O_2 = Pre-test before treatment
X_1 = Learning in the experimental class with CPS-SSI
X_2 = Learning in the control class with Discovery Learning

The population comprised 72 Grade X students from two classes, X-7 and X-6, each consisting of 36 students. The sample size was determined using the Slovin formula, resulting in 61 students, with 31 assigned to the experimental class and 30 to the control class. The Creative Problem Solving model integrated with socio-scientific issues (CPS-SSI) was implemented in the experimental class, while the control class received conventional biology instruction. This design allowed for a focused comparison of learning outcomes between the two groups.

The instrument was an essay test comprising 8 items. Instrument validity was examined using the Product Moment correlation, and all items were found to be valid, while The reliability analysis indicated a Cronbach's Alpha coefficient of 0.64 indicating moderate reliability. Data obtained from the test were analyzed using t-test statistics with the aid of SPSS version 27. The analysis included prerequisite tests of normality and homogeneity, followed by an independent t-test at a significative level of $\alpha = 0.05$.

During the preparation phase, socio-scientific issue–based test instruments in the form of pretests and posttests were developed to measure the effect of the Creative Problem Solving model on students' creative thinking skills in environmental change topics. Subsequently, two classes were selected as the research sample and assigned as the experimental and control groups. Class X-7 was designated as the experimental group and received Creative Problem Solving instruction integrated with socio-scientific issues, while Class X-6 served as the control group and was taught using the Discovery Learning model.

During the implementation step, the experimental class was taught water pollution and greenhouse effect topics using PowerPoint media and instructional materials based on the CPS–SSI model. In contrast, the control class received the same materials through the Discovery Learning model without CPS–SSI integration. After the material was delivered, a posttest was administered, the questions were based on SSI. The posttest was administered to both the experimental and control classes to measure creative thinking about environmental change.

In addition, this study used two observation instruments, a teacher activity observation sheet and a student activity observation sheet. The teacher observation sheet recorded teaching practices during classroom discussions, while the student observation sheet measured student participation levels. Both instruments used a 5 point Likert scale checklist based on direct classroom observations. The observation aimed to determine the extent to which the learning process was implemented in both classes.

RESULTS AND DISCUSSION

The application of the Creative Problem Solving model integrated with CPS–SSI was conducted through several structured stages. Learning began with the presentation of

contextual socio-scientific issues related to environmental change to stimulate students' problem awareness. Students then identified problems, generated ideas, and proposed alternative solutions through guided discussion and collaborative activities. The proposed solutions were evaluated using scientific concepts to determine the most appropriate and feasible options. Finally, students communicated their conclusions and reflections, thereby fostering creative thinking and contextual understanding.

Based on the average pretest scores, both classes have relatively close scores, as shown in Table 2.

Table 2. Results of the creative thinking ability test

Class		*n*	Minimum value	Maximal value	$\bar{X}$	SD	*Gain Score*
CPS-SSI	Pretest	31	28.00	59.00	47.29	8.89	68.36
	Posttest		72.00	97.00	83.42	5.09	
DL	Pretest	30	25.00	53.00	46.23	6.32	44.92
	Posttest		62.50	84.00	70.67	6.06	

This indicates that the two classes had similar initial abilities. However, after the treatment, the experimental group achieved a significantly higher average posttest score than the control group. This aligns with research conducted by Richardo & Kholifah (2023), which found that posttest results for the experimental and control classes differed, indicating that after treatment, the two groups had different abilities.

The average pretest score was 47.29 in the experimental class and 46.23 in the control class. The minimal initial difference in creative thinking ability between the experimental and control groups is considered reasonable, as students previously relied only on basic or prerequisite material (Senjayawati, 2020). This indicates that the creative thinking abilities of the two classes are showed no significant difference. Therefore, the sample was declared suitable for research (Wafiyah et al., 2020).

The average posttest score was 83.42 in the experimental class and 70.67 in the control class. The experimental class achieved a significantly higher posttest score than the control class, indicating that students' creative thinking skills improved after participating in the CPS-SSI learning model. This agrees with previous research by Hsm et al. (2021), which suggests that the CPS learning model is a viable alternative due to its problem-based characteristics, making it suitable for enhancing creative thinking skills. The different posttest scores were due to the different learning models applied in the experimental and control classes. Innovative learning can teach students to develop their creative thinking skills, there by generating new and more effective ideas (Hasriadi, 2022).

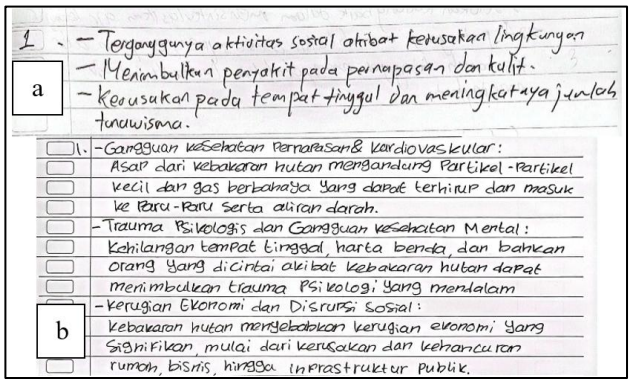
Furthermore, there was a decrease in the standard deviation after the posttest in both groups, the experimental class showed a smaller decrease in standard deviation, indicating that the answers were more varied in the experimental class. This finding agrees with prior research reported by Muhlisin et al. (2021), which reported that the standard deviation in the experimental class was smaller, indicating that the answers were more varied compared to the control class, which had less varied answers. The gain score represents the difference between pretest and posttest results and is used to measure the advancement in students' thinking skills after the treatment. A higher gain score indicates greater improvement in creative thinking skills. Based on the gain score data in Table 1, both classes showed a significant increase from pretest to posttest, categorized as moderate.

The average values of each indicator on the creative thinking ability test are presented in Table 3.

Table 3. Results of the creative thinking ability test

Indicator	CPS-SSI				DL			
	n	Pretest $\bar{X}$ (±SD)	Posttest $\bar{X}$ (±SD)	N-Gain (category)	*n*	Pretest $\bar{X}$ (±SD)	Posttest $\bar{X}$ (±SD)	N-Gain (category)
Fluency	31	58.06 (13.13)	93.55 (7.82)	0.81 (High)	30	57.92 (12.05)	77.50 (14.46)	0.43 (Currently)
Flexibility		51.61 (12.61)	81.85 (10.12)	0.59 (Currently)		47.50 (16.22)	70.00 (9.63)	0.39 (Currently)
Originality		46.37 (18.03)	78.63 (9.24)	0.54 (Currently)		41.67 (11.05)	67.50 (10.17)	0.41 (Currently)
Elaboration		36.84 (27.04)	83.47 (12.24)	0.50 (Currently)		38.33 (18.26)	67.50 (10.69)	0.43 (Currently)

In the experimental class, the highest average indicator score in both the pretest and posttest was observed in the Fluency indicator, which also showed the highest n-gain. Similarly, in the control class, the highest average indicator score in both the pretest and posttest was found in the Fluency indicator. The highest n-gain was found in the Fluency and Elaboration indicators in the control class. Figure 1 show sample pretest and posttest answers from the experimental and control classes, which showed the highest improvement in the fluency thinking indicator on the creative thinking ability test results.



Give a concrete example of the main impact of environmental change on human life!
Answer:

a. *- Disruption of social activities*
   - Causes respiratory and skin diseases
   - Damage to housing

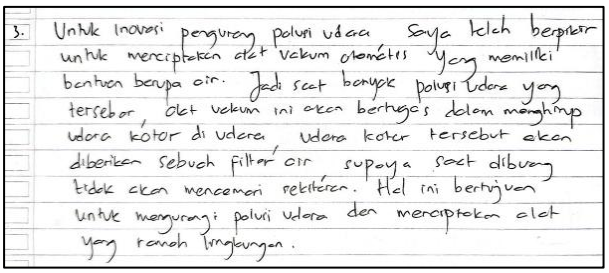
b. *- Respiratory and cardiovascular health problems: Smoke from forest fires contains small particles and dangerous gases that can be inhaled and enter the lungs and bloodstream*
   - *Psychological trauma: Losing homes, possessions, and even loved ones due to fires can cause profound psychological trauma*
   - *Economic losses: Forest fires can cause significant economic losses, ranging from damage and destruction to homes, businesses, and public infrastructure.*

Figure 1. (a) Pre-test answers for the experimental class fluency thinking indicator and (b) post-test answers for the experimental class fluency thinking indicator

The Fluency indicator point to students' ability to produce diverse ideas (Torrance, 1988). Students in the experimental class excelled in the Fluency indicator for generating new ideas compared to the control class, because students produced various creative solutions without being limited by right or wrong. This finding one way with study conducted by Cahyani et al. (2022), which revealed that the Fluency indicator yielded the highest percentage of scores, indicating that most students already possessed this skill. This was due to students' ability to think creatively to produce concepts in answering questions. Students with high Fluency indicators were able to generate various ideas and answers fluently. The more answers they had, the higher the level of students' Fluency ability. Students who correctly answered questions from the Fluency indicator were able to generate numerous ideas, answers, or solutions (Nurhanifah, 2022). The use of pretests and posttests in SSI based learning revealed significant differences between pretest and posttest results, suggesting that SSI can enhance

creative thinking skills (Nubita & Istianah, 2022). Integrating SSI allows students more freedom to relate material to contextual phenomena or their own experiences, which can generate diverse ideas. This resulted in a superior Fluency indicator in both classes.

The next indicator is Flexibility, which helps students generate ideas from various perspectives that can be implemented to solve problems (Munandar, 2012). Students in the experimental class demonstrated higher Flexibility scores in both the pretest and posttest. Student propose multiple solutions from different perspectives, as they position themselves as environmental experts.

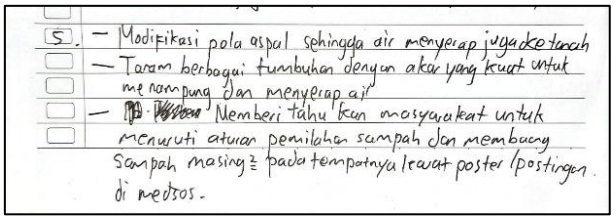

3. Untuk inovasi pengurang polusi udara saya telah berpikir untuk menciptakan alat vakum otomatis yang memiliki bentuk berupa air. Jadi saat banyak polusi udara yang tersebar, alat vakum ini akan bertugas dalam menghirup udara kotor di udara. Udara kotor tersebut akan diberikan sebuah filter air supaya saat dibuang tidak akan mencemari refleksi. Hal ini bertujuan untuk mengurangi polusi udara dan menciptakan alat yang ramah lingkungan.

What technologies can you create to address environmental change?
Answer:
Create an automatic vacuum cleaner using water. When air pollution is high, this vacuum cleaner will function to inhale the polluted air. The polluted air will be filtered through a water filter, so it won't pollute the environment when released. This aims to reduce air pollution and create an environmentally friendly device.

Figure 2. Post-test answers for the experimental class flexibility thinking indicator

These findings align with previous research by Sukarso & Muslihatun (2021), which showed that the Fluency and Flexibility indicators had the highest average scores. SSI based learning activities can encourage students to combine ideas to solve emerging problems (Rahmawati et al., 2018). Therefore, students in the experimental class were more effective at generating varied solutions than those in the control class.

The next indicator is Originality, which point to students' ability to generate innovative and unique ideas (Kim, 2011). The results point out that the experimental class obtained higher scores in originality on both the pretest and posttest, as presented in Figure 3. The following answer reflects the originality indicator, as students propose ideas that are rarely generated by others.


5. — Modifikasi pola aspal sehingga air menyerap juga ke tanah
— Taram berbagai tumbuhan dengan akar yang kuat untuk menampung dan menyerap air
— Memberi tahu kan masyarakat untuk mematuhi aturan pemilahan sampah dan membuang sampah masing2 pada tempatnya lewat poster/postingan di medsos.

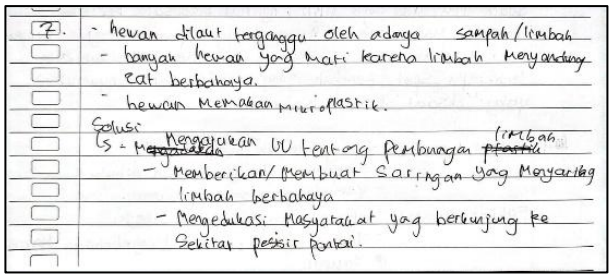
Suppose you are a government policymaker, an environmental activist, or a major businessperson with a significant impact on the environment. In a group discussion, you are asked to find the best solution to address one of the environmental problems you and your group have analyzed. Explain how this idea could be implemented in Indonesia!
Answer:
- *modify asphalt patterns so water can absorb into the soil*
- *plant various types of plants with strong roots to absorb water*
- *inform the public to comply with waste sorting regulations and dispose of waste according to its proper receptacle/type, which can be disseminated through posters or posts on social media.*

Figure 3. Post-test answers for the experimental class originality thinking indicator.

This indicator had the lowest average score of the two classes. Originality requires the ability to generate creative solutions that have never been considered before. This is because students think of ideas that are common or have not been considered by them. This is in line with research by Nufus (2021), which states that several factors contribute to low creative thinking skills in students, such as students tending to focus on the teacher's teaching methods and students not exploring or practicing enough.

The final indicator is Elaboration, which refers to students' ability to develop ideas by providing additional information, concrete examples, or further explanations (Munandar, 2009). The results represent that the average

Elaboration score in the experimental class was higher than in the control class. This indicates that students in the experimental class demonstrated a more comprehensive understanding and more complex thinking skills. The following are examples of students' responses in the experimental class. The elaboration indicator is achieved when students develop ideas in detail, although the following answer does not explain how to implement it.



Explain the appropriate steps you will take in your daily life to help reduce the negative impact on the environment, especially in your home environment!
Answer:
- Animals in the sea are disturbed by waste
- Many animals die from hazardous substances
- Animals eat microplastics
Solution:
- Enact laws on waste disposal
- Create filters to filter hazardous waste
- Educate the public.

Figure 4. Post-test answers for the experimental class elaboration thinking indicator.

This finding one way with previous research by Aziz & Prasetia (2021), which suggests that the practice of the CPS learning model can enhance students' creative thinking skills when solving problems. SSI based learning also helps students better understand the material and relate it to everyday life. This is reinforced by the opinion of Zeidler & Nichols (2009), who stated that SSI can help students make informed decisions, improve their thinking skills, and provide an engaging context for learning.

Creative Problem Solving based on Socio-Scientific Issues implemented in the experimental class actively engages students in identifying, analyzing, and solving problems derived from current socio-scientific issues. The teacher facilitates students' creative and critical thinking through CPS stages, including problem understanding, idea generation, and solution selection. This finding indicates that the syntax of the learning model influences the measured variables, as the learning model syntax consists of specific instructional steps that must be implemented to apply the learning model (Azrai et al., 2022).

In contrast, Discovery learning implemented in the control class emphasizes students' processes of discovering concepts through observation, data collection, and conclusion. The teacher directs students to explore the phenomenon of environmental change without any connection between science and social issues in everyday life. Students only provide existing solutions, without thinking about what solutions they can provide to reduce environmental pollution. This is what makes CPS-SSI learning superior in the experimental class.

The output of the learning implementation observations were compiled based on the syntax of the learning activities in the teaching module that had been created. The CPS-SSI learning syntax can be visible in table 4.

Table 4. Instrument grid for implementation of experimental class

CPS Syntax	Teacher Indicators	Student Indicators
Objective finding	Presents a problem that stimulates students creative thinking	Think about various goals or objectives that can guide their creative thinking
Fact finding	Guides students to identify facts related to the learning topic	Search for and identify relevant and important facts related to the topic
Problem finding	Proses guiding questions to help students identify problems that need to be solved	Formulate the given problems
Idea finding	Encourages and appreciates the creative ideas proposed by students	Generate various creative ideas as potential solutions to the given problems

CPS Syntax	Teacher Indicators	Student Indicators
Solution finding	Guides students in evaluating the ideas that have been generated	Evaluate the results of the discussion
Acceptance finding	Facilitates group presentations to obtain feedback from pers and helps students make conclusions by connecting them to real life contexts	Present their group work, reflect on the learning process and receive feedback

Based on the findings observations, the average percentage of learning implementation in both the experimental and control classes was categorized as very good. The results are presented in Table 5.

Table 5. Percentage of learning implementation

Class	1	2	Average
Experiment	91.53%	93.07%	92.30%
Control	84.34%	93.91%	89.12%

The effectiveness of the CPS-SSI model implementation and the level of achievement of students' creative thinking skills in the experimental and control classes are influenced by the learning implementation process in the classroom. The experimental class reached an average score of 92.3%, while the control class reached an average score of 89.1%, both of which fall within the very good category (Riduwan, 2013). Effective learning implementation suggests that teachers can make a conducive and engaging learning atmosphere (Zainuddin & Hardiansyah, 2023). This finding is consistent with Rahayu & Hardini (2019), who stated that effective learning implementation indicates that teachers successfully engage students actively by organizing material in a way that facilitates understanding.

The implementation of learning in the control class was lower due to limited instructional time and low student participation, as only a few students responded to the teacher's questions. This finding corroborates previous results reported by Trias et al. (2022), who reported that rapid instructional delivery can hinder students' conceptual understanding. Therefore, optimizing question-and-answer discussions during instruction may serve as an effective solution, as demonstrated by through the effective use of instructional time (Nur et al., 2022).

The outcome of the normality and homogeneity tests yielded significance values greater than 0.05, indicating that H0 was accepted and that the data were normally distributed and homogeneous. Furthermore, the effectiveness of the learning model in improving students' creative thinking skills was measured using the normalized gain (N-gain) value. Based on the results of the normalized gain calculation, both models are included in the moderate category. Although creative thinking skills increased in the experimental class, the improvement did not reach an optimal level. This limited improvement may be attributed to students' lack of prior experience with creative thinking, which requires time for adaptation and idea generation.

Table 6. Experimental and control N-Gain value categories

Class	N-Gain	Category
Experiment	0.68	Currently
Control	0.45	Currently

Based on Table 7, the gain score falls within the moderate category, indicating that the CPS-SSI learning model improved students' creative thinking skills on environmental change topics.

Table 7. Independent t-test results

	t	df	Sig (2-*tailed*)	α	Conclusion
Gain Score	8.253	59	< 0.001	0.05	H_0 rejected

This indicates that the CPS model can encourage students to actively participate in group discussions, understand, solve problems, answer questions, and synthesize opinions (Herlawan & Hadija, 2017). This research is

involved to the results of previous research conducted by Azizah & Santoso (2023), which indicates that the CPS model can enhance students' creative thinking skills. Furthermore, CPS can provide challenges and encourage students by training them to develop their problem-solving skills (Sari et al., 2020).

SSI based learning can involve scientific topics that encourage students to discuss (Zeidler & Nichols, 2009). In the context of this study, the CPS-SSI model can help students actively participate in a learning process that involves real-life exploration, specifically focusing on the topic of environmental change. The alignment between the learning model syntax and its implementation influences the effectiveness of the learning process. Effective learning occurs when teachers master the model syntax, which is systematically designed and properly evaluated (Tosin et al., 2023).

The improvement of creative thinking skills requires the implementation of strategic instructional approaches, including interactive learning models (Sigit et al., 2023). Therefore, research using the CPS model can improve students' creative thinking skills. This is supported study by Andrias et al. (2019) that the CPS model can be considered a learning model that encourages students to actively participate in conveying creative ideas, resulting in deep learning experiences and understanding over a long time. By integrating SSI into learning, it can facilitate active learning. This is also proven by Siribunnam et al. (2019), who found that SSI has the potential to increase learning interest through discussions based on scientific information.

CONCLUSION

Based on the findings, the CPS-SSI learning model effectively enhances students' creative thinking skills on environmental change topics, as indicated by moderate gain scores. This improvement occurs because CPS-SSI encourages students to think flexibly, originally, and elaboratively through engagement with real socio-scientific issues. Therefore, CPS-SSI can serve as an alternative instructional approach to foster creative thinking. This study was limited by a short instructional duration and a relatively small sample from a single school. In addition, the study focused on cognitive. It is hoped that future studies can expand its application to non-cognitive aspects such as environmental awareness.

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