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Original Research Article

Enhancing creativity skills and student learning outcomes through the implementation of creative problem solving model with mind mapping on salt hydrolysis topic

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ABSTRACT

In the face of increasing demands for 21st-century skills, chemistry education must advance to better support students in developing problem-solving abilities. Effective chemistry learning models are crucial in addressing this need. This study examines the impact of the Creative Problem Solving (CPS) model, equipped with the Mind Mapping method, on students' creative thinking skills and cognitive learning outcomes in salt hydrolysis. A quasi-experimental method with a pretest-posttest control group design was used in this research. Cluster random sampling was employed for sample selection. The sample consisted of 72 students from a school in Surakarta City. Data were collected using a test instrument with eight essay questions to assess creative thinking skills and six essay questions to evaluate cognitive learning outcomes. Non-parametric statistical tests were utilized for data analysis. The results of the Kruskal-Wallis's test produce sig. (0.000 < 0.05) which means the hypothesis is accepted. The results showed that applying the CPS learning model with mind mapping affected students' creative thinking skills and cognitive learning outcomes so that it can be used as an alternative learning model to improve 21st-century skills. This research contributes new insights into applying the Mind Mapping-assisted CPS learning model for chemistry education.

Introduction

The 21st century is characterized by the rapid development of information technology and science, resulting in a paradigm shift in human life (Marshel and Ratnawulan, 2020). 21st-century learning is required to integrate 21st-century skills, which include students' abilities in fulfilling aspects of knowledge, skills, attitudes, and mastery in the development of information and technology as a provision for students to face the challenges of the 21st century (Septikasari and Frasandy, 2018). Critical thinking, collaboration skills, communication, and creative thinking are skills that students must have in 21st century education (Shidiq and Yamtinah, 2019). Creativity is one of the skills students need to face the demands of the 21st century. Creative thinking skills are referred to by the National Qualifications Framework for Higher Education as one of the higher-order thinking skills that focus on developing the skills of all students (Songkram, 2015). Based on PISA data in 2022, Indonesia is ranked 69th out of 81 participating countries, indicating that students' creative thinking skills in Indonesia tend to be lower than in other countries (OECD, 2023).

Considering the importance of creative thinking skills for students, the learning process in schools must be designed so that students have the greatest opportunity to develop their creative thinking skills, including chemistry subjects. Chemistry is the proper science to improve 21st-century skills, namely encouraging students to have the 4C Skills (Critical Thinking, Communication, Collaboration, and Creativity) (Nuraeni et al., 2019). However, most students still need help understanding chemistry (Wahyudiati, 2022). Chemistry is complex for students to understand because of its abstract and complex nature (Supriono and Rozi, 2018). Salt hydrolysis is one of the chemicals in high school that students consider difficult (Umami et al., 2020). Students have difficulty in understanding salt hydrolysis topic on indicators determining the type of salt hydrolyzed in water, determining the properties of hydrolyzed salt, calculating the pH of hydrolyzed salt solutions, and concluding experimental results to determine the kind of salt hydrolyzed (Shidiq et al., 2019). One solution to overcome this problem is to choose a suitable learning model to achieve the goals of learning chemistry in the 21st century.

21st-century chemistry learning emphasizes the process of seeing, understanding, studying, predicting, classifying, concluding, and communicating topic to develop students' ability to solve a problem (Prayunisa, 2022). According to Hu (2017), problem-solving learning must be instilled in students to hone their creative thinking skills. According to Fadillah (2016), if students' creative thinking skills are not considered, it will affect their' creative thinking skills, and student learning outcomes will not be achieved optimally. This aligns with Lin and Wu's (2016) research, which found that creative thinking skills positively correlate with cognitive learning outcomes. Researchers have conducted research related to the application of learning models to students' creative thinking skills and cognitive learning outcomes (Apino and Retnawati, 2018; Fadhil et al., 2021; Ndiung et al., 2021; Supena et al., 2021). New studies are needed to evaluate specific activities that can improve creative thinking skills (Forte-Celaya et al., 2021).

One learning model that can be applied to improve students' creative thinking skills and cognitive learning outcomes is the Creative Problem Solving (CPS) model (Yanti et al., 2019). The CPS learning model refers to problem-solving and strengthening creative thinking by applying divergent thinking skills to identify or clarify a problem and develop an ideal solution (Kettler et al., 2018; Van Hooijdonk et al., 2020). The selection of the CPS learning model will place students in an actual situation; through creative problem-solving skills, students will gain significant knowledge (Van Hooijdonk et al., 2023). In addition, the CPS model allows students to become bored because students have to solve complex problems with various alternative answers (Ningsih et al., 2023). To optimize the application of the CPS model, it is necessary to integrate the help of methods or media in its application in learning. One form of assistance that can be applied to the CPS model is Mind Mapping.

Mind mapping combines images with text to create knowledge between topic keywords and allows the brain to store the information conveyed effectively (Wu and Wu, 2020). According to Bawaneh (2019), the application of Mind Mapping in learning has advantages including being able to increase concentration in learning, making it easier to understand written data because it is converted into formulas, changing verbal form communication into pictures, symbols, and diagrams, making right and left brain functions balanced, increasing motivation to learn, and presenting data in an exciting form. Gavens' research (2020) results say that Mind Mapping helps students remember information faster. Mind mapping is integrated into CPS syntax so that problem-solving activities can be arranged systematically and effectively to achieve learning objectives. In addition, integrating mind mapping can train creativity, which is expected to improve students' creative thinking skills and cognitive learning outcomes.

Several relevant previous studies support this research. Malisa's research (2018) shows that the implementation of chemistry learning using the CPS learning model has succeeded in improving students' cognitive learning outcomes. Research by Risnawati and Parham (2016) shows that applying the CPS learning model to buffer solution topic can improve students' cognitive learning outcomes and creative thinking skills on originality, fluency, elaboration, and flexibility indicators. However, research by Safira and Anwar (2020) shows that the CPS model assisted by mind mapping does not have a significant effect on chemistry learning outcomes in colloid topic. Therefore, research on integrating CPS model with mind mapping in the teaching of chemistry still needs to be explored. This study aims to find out the effect of the Mind Mapping-assisted CPS learning model on salt hydrolysis topic on students' creative thinking skills and cognitive learning outcomes. This research hopes that the Mind Mapping-assisted CPS model can be a means to train students' creative thinking skills and as a solution to overcome students' low cognitive learning outcomes.

Methods

Research Design

This research includes quantitative research using quasi-experimental methods with a pretest-posttest control group design (Miller et al., 2020). The experimental class applied the Mind Mapping-assisted CPS learning model, while the control class used the Discovery Learning learning model for two meetings. The population in this study was all grade XI MIPA students in one of the schools in Surakarta City, with as many as 248 students. Sampling was carried out using cluster random sampling technique where from a population of 7 classes, two classes were taken as experimental classes (N = 36) and control classes (N = 36). Homogeneity between the classes was tested based on their odd semester chemistry PSAS scores. The following is Table 1, which shows the research design used in this study.

Table 1. Research design

Class	N	Pretest	Treatment	Posttest
Experiment	36	O1	X1	Q1
Control	36	O2	X2	Q2

Information:

O1	:	Experimental Class Pretest	O2	:	Control Class Pretest
X1	:	learning with the Mind Mapping-assisted CPS model	X2	:	learning with the Discovery Learning model
Q1	:	Posttest experimental class	Q2	:	Posttest control class

Instrument

The instrument used in this study is a test method: a description test of 8 questions for creative thinking skills and six questions for cognitive learning outcomes. Before being used in this study, the test instrument was validated by two expert validators. To determine whether the validity of an instrument's contents meets the requirements, use the Gregory formula, where the instrument can be used if the CV > 0.7. Based on the validation results, a CV of > 0.7 is obtained so that the test instrument is valid and can be used. The aspects of creative thinking skills in this study are presented in Table 2, referring to the Guilford theory, namely fluency of thought, flexibility of thinking, original thinking, and elaboration. The integration of the CPS model with Mind Mapping on creative thinking skills in this study is presented in Table 3.

Table 2. Creative thinking skills indicators

Indicator	Sub Indicators
Fluency	Express any ideas or ideas smoothly. Plan and use many ways to solve problems.
Flexibility	Trigger various interpretations of a problem, image, or question. Can see a problem from a different perspective.
Elaboration	Develop, add, and enrich an idea or product. Go into detail step by step to find a deeper meaning in an answer.
Originality	Creating new answers that are unique (not yet thought of by others). Able to make unusual combinations of parts or elements.

Table 3. Integration of CPS with mind mapping on creative thinking skills

Sintaks Model CPS (Osborn-Parnes)	Use Mind Mapping	Emphasized indicators
Objective Finding	-	Fluency Originality
Fact Finding	-	Fluency Flexibility
Problem Finding	-	Flexibility Originality
Idea Finding	Students express their ideas and ideas creatively by making Mind Mapping related to solving LKPD.	Fluency Flexibility Elaboration Originality
Solution Finding	Students in groups present the results of discussions and Mind Mapping made in front of the class and evaluate the results of Mind Mapping that other groups have made.	Fluency Elaboration
Acceptance Finding	Students and teachers make conclusions about problem-solving solutions based on the results of Mind Mapping that have been evaluated.	Flexibility Elaboration

Data Analysis

Data processing in this study used SPSS 25 software. Students' cognitive learning outcomes and creative thinking skills were evaluated using description tests on the pretest and posttest. The N-Gain test was conducted to determine how much students improved before and after implementing classroom learning treatment. The resulting N-Gain score will be categorized based on the level of interpretation shown in Table 4.

Table 4. Interpretation of N-Gain scor

Gain Factor (g)	Criterion
(g) > 0.7	Tall
0.3 ≤ (g) ≤ 0.7	Keep
0 (g) < 0.3	Low

The prerequisite analysis test in this study is in the form of a normality test and a homogeneity test. The hypothesis test using the Kruskal-Wallis test with a significance level of $\alpha = 0.05$. If a significance value of < 0.05 is obtained, it shows a significant difference in the average value of the control and experimental class variables.

Results

Table 5 shows data on students' cognitive learning outcomes and creative thinking skills of the control and experimental classes reviewed from the pretest and posttest. Based on Table 5, it can be seen that the N-Gain score of the experimental class is higher than that of the control class with the criterion of "high." While the N-Gain score of the control class with the criterion of "medium." This showed an improvement in creativity skills and cognitive learning outcomes of the experimental class compared to the control class.

Table 5. Description of student pretest and posttest score data

Class	N	Mean		<g>	Criterion
		Pretest	Posttest		
Creative Thinking Skills					
Control	36	29.77	73.96	0.63	Medium
Experiment	36	29.34	83.77	0.77	High
Cognitive Learning Outcomes					
Control	36	30.83	73.89	0.62	Medium
Experiment	36	30.56	81.67	0.74	High

Table 6 shows the results of normality tests of students' creative thinking skills and cognitive learning outcomes in experimental and control classes. The normality test was performed using the Shapiro-Wilk test with a significance level of > 0.05. Based on the results of the normality test, sig is obtained. > 0.05, so it can be known that the data is usually distributed.

Table 6. Normality test results

Normality Test	Sig.	Results	Conclusion
Creative Thinking Skills			
Control Class	0.592	H0 accepted	Normal
Experimental Class	0.081	H0 accepted	Normal
Cognitive Learning Outcomes			
Control Class	0.113	H0 accepted	Normal
Experimental Class	0.201	H0 accepted	Normal

Table 7 shows the homogeneity test results of students' cognitive learning outcomes between the experimental and control classes. The homogeneity test was carried out using the Levene Test with a significance level of > 0.05. Based on the results of the normality test for creative thinking skills, sig is obtained. > 0.05, so it can be known that the data has a homogeneous variance. Meanwhile the results of the normality test for cognitive learning outcomes, sig is obtained. < 0.05, so it can be known that the data are not homogeneous.

Table 7. Homogeneity test results

Levene Test	Sig.	Results	Conclusion
Creative Thinking Skills	0.342	H0 accepted	Homogeneous
Cognitive Learning Outcomes	0.001	H0 rejected	Not Homogeneous

Table 8 shows the results of the Kruskal-Wallis test with a significance level of α = 0.05. Based on the results of the hypothesis test, sig was obtained. (0.000 < 0.05) so that it can be concluded that there is a significant difference in the average variable of the experimental class from that of the control class.

Table 8. Hypothesis test results

Multivariate Tests	N	Sig.	Results	Conclusion
Experiment	36	0.000	H0 rejected	There is a significant difference
Control	36			

Discussion

The Effect of Mind Mapping-assisted CPS Learning Model on Students' Creative Thinking Skills

The implementation of the CPS learning model assisted by Mind Mapping is in accordance with the principles of 21st century chemistry learning which emphasizes students on the process of seeing, understanding, examining, predicting, classifying, concluding, and communicating material to develop students' problem-solving abilities (Prayunisa, 2022). The Creative Problem Solving (CPS) learning model in this study refers to the Osborn-Parnes syntax, which consists of six syntaxes: objective finding, fact-finding, problem finding, idea finding, solution finding, and acceptance finding (Osborn, 1953). The Mind Mapping method is integrated into the implementation of learning syntax in the classroom. Fig-1 shows the achievement of each indicator of creative thinking skills in the experimental class with the control class. The percentage of achievement of each indicator of creative thinking in the experimental class is higher than in the control class because of the treatment in the form of applying a creativity-based problem-solving model with mind mapping being directed at activities that confront students with real problems in everyday life (Patmawati et al., 2019). The results of this study show that the results are in accordance with the research of Meiarti et al. (2020) which shows that the CPS model assisted by Mind Mapping is able to improve students' creative thinking skills.

According to Lin and Wu (2016), Creative thinking is the habit of thinking, using intuition, and finding unusual ideas that allow students to develop new ideas. High creative thinking skills in experimental classes are caused by learning directed at activities that expose students to real problems in everyday life (Patmawati et al., 2019). The application of the CPS learning model can develop students' ability to solve problems creatively (Kim et al., 2019). This allows students to develop their thinking and relate their knowledge to various problem-solving ideas. Making Mind Mapping also involves students' creative power, Vitulli and Giles (2016) stated that Mind Mapping helps students organize ideas creatively. Through Mind Mapping, learning activities will foster student motivation and activeness in learning (Leontyeva et al., 2021). Mind Mapping helps students learn more creatively and have a strong imagination (Sezer and Polat, 2022).

Making Mind Maps effectively can support the development of students' creative thinking skills indicators (Khoerudin et al., 2023). The process of students generating many ideas or concepts related to the main topic in making Mind Maps can increase student fluency. The process of students connecting various ideas or information in varied and creative ways allows students to explore various perspectives or approaches to a topic, thereby increasing student flexibility. Then, the process of students generating new and previously unthinkable ideas or concepts in Mind Mapping encourages increased student originality. The process of students developing ideas by adding details, sub-topics, or deeper connections between elements in Mind Mapping supports increased student elaboration. Overall, the steps in making Mind Mapping directly support the development of various indicators of creative thinking skills (Meiarti et al., 2020).

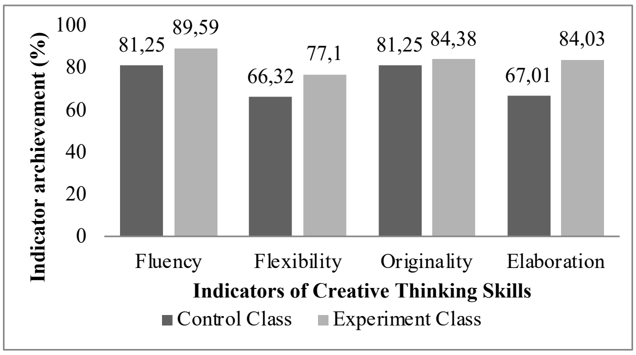

Fig-1. Achievement results of creative thinking skills

Indicators of creative thinking skills in this study refer to the theory of Guilford (1984), namely fluency, flexibility, originality, and elaboration. The first indicator is fluency. Fluency is students' creativity in generating many ideas and answers or solving a problem (Fatma, 2021). Fluency indicators are seen in the implementation of objective finding syntax when students identify issues, fact-finding when students collect facts related to problems, idea finding when students compile ideas as solutions to problems in the form of Mind Mapping, and in solution-finding syntax When students analyze the solution to the problem then determine the best problem-solving. A series of activities can build students' skills to generate many ideas or ideas that are then used to solve problems. Problem-solving through group discussions is the right strategy for students to smoothly express new ideas/ideas with group friends (Agustin, 2021).

The second indicator is flexibility. Flexibility is the ability of students to produce diverse ideas, ideas, answers, or questions and see problems from various points of view (Wakhid et al., 2023). Flexibility indicators are seen in the implementation of fact-finding syntax when students collect facts related to problems viewed from various points of view, idea finding when students compile ideas as solutions to problems in the form of Mind Mapping, problem finding when students identify all facts and then choose the main problem through group discussion, and in the syntax of acceptance finding When students make conclusions related to problem-solving solutions that have been evaluated together. The series of activities requires students to think creatively and find new ideas. This is reinforced by Agustin (2021), who states that students can hone flexibility skills through discussions with group friends during the learning process.

The third indicator is originality. Originality is the ability to think in other ways (new) or with unique expressions (Rasnawati et al., 2019). Originality indicators are seen in the implementation of objective finding syntax when students identify problems, problem finding when students identify all facts and then choose the main issue, and idea finding syntax when students detail new ideas obtained to solve problems in Mind Mapping. The maximum student thinking process is based on direct student involvement in solving a problem so that students can develop unique/original thinking skills (Elfiani, 2017).

The fourth indicator is elaboration. Elaboration is the ability of students to detail things in detail from an idea, object, or situation (Rasnawati et al., 2019). Elaboration indicators are seen in the implementation of solution-finding syntax when students present the results of discussions and Mind Mapping smoothly and in detail in front of the class and acceptance-finding syntax when students enrich ideas related to problem-solving solutions that have been evaluated together. A group discussion process makes it easier for students to consider the solution to the existing problem so that they can write and detail things related to the solution (Elfiani, 2017).

Based on Fig-1, the achievement of experimental class indicators with the highest percentage is the fluency indicator, and the lowest is flexibility. The highest achievement of creative thinking skills is in the fluency indicator; this is influenced by the work of CPS-based LKPD assisted by Mind Mapping, which presses students to produce many ideas in a limited time and is supported by students' natural ability to be able to generate many new concepts or ideas. This is by the research Handayani (2021) where the fluency indicator has a higher achievement than the other three indicators of creative thinking skills. The flexibility indicator has the lowest achievement compared to other indicators because students are less encouraged to practice solving complex problems. Students are rarely allowed to practice finding various solutions to solving problems, hindering their flexibility (Wijaya et al., 2022).

The Effect of the Mind Mapping-assisted CPS Learning Model on Student Cognitive Learning Outcomes

Cognitive learning outcomes are the results of achievements that include cognitive fields and knowledge after student learning efforts based on working on the topic that students have learned during the learning process (Alianto et al., 2021; Tika and Agustiana, 2021). This study uses content differentiation learning and process differentiation by grouping students into three categories of: readiness to learn (readiness), very proficient students, students who are pretty skilled, and students who need guidance. Differentiated learning gives students the freedom to learn comfortably, according to their potential, so they feel comfortable in the learning atmosphere created by the teacher (Fitra, 2022). Based on the achievement of students' after treatment, the treatment presented shows the difference in the percentage of cognitive learning outcomes between students in the experimental and control classes. The achievement rate of indicators in the experimental class was 81.67%, while in the control class was 73.89%. This percentage shows that the achievement of student learning outcomes in the experimental class is higher than that of students in the control class. This is supported by the results of the N-Gain test score in the experimental class of 0.74 with the "high" criterion while in the control class of 0.62 with the "medium" criterion. However, applying the CPS and Discovery Learning models affects student cognitive learning outcomes, reflected in the increased scores in the salt hydrolysis topic post-test. This aligns with Kurnianto's (2016) research that the Discovery Learning model affects student achievement in knowledge and skills in salt hydrolysis topic. The discovery learning model can encourage student exploration and discovery which can have an impact on improving students' cognitive abilities (Hartadiyati et al., 2023).

The CPS learning model suppresses the right brain of creativity-based students (Hasan et al., 2024). The application of the CPS model has a positive impact on improving students' ability to balance creative problem-solving with understanding the concepts they have. This increases student learning outcomes after being treated with the creative problem solving learning model. This result aligns with the research that shows the creative problem solving model can improve learning outcomes on salt hydrolysis topic. In addition, the results of this study are also in line with the research of Erfawan and Nurhayati (2015) in the form of a CPS learning model that is effectively able to improve the chemistry learning outcomes of high school students, solubility topic and solubility results which show the average learning outcomes of the experimental group are higher than the control group.

Mind Mapping can help students remember the topic learned so that the learning carried out becomes meaningful learning. According to Jain (2015), mind mapping makes it easier for students to create unlimited ideas and associate with any topic to master the topic taught. Mind Mapping trains students' brains to develop problem topics creatively expressed in colorful images so that students easily remember what has been done. It can become long-term memory for students, which will later affect better student cognitive learning outcomes. This is supported by Fitriyah (2015) who stated that the CPS learning model with Mind Mapping trains students to solve problems creatively, which is poured into Mind Mapping so that students do not feel bored in the teaching process in class. Making and using mind mapping helps students understand a topic or problem and find the right solution. The results of this study show that the results are in accordance with the research of Pandaleke (2023) which shows that the CPS model assisted by Mind Mapping is able to increase science learning outcomes in the human digestive system topic.

Research Excellence and Limitations

Based on the results, the Mind Mapping-assisted CPS learning model can affects students' cognitive learning outcomes and creative thinking skills. The implementation of the CPS model assisted by Mind Mapping is proven to facilitate students to explore knowledge and increase student sensitivity in dealing with problems in the real world so that students can bring out their creative thinking in providing solutions to the issues that arise around students. Although the results showed promising results, there is a limitation to this study, which is that it only uses two classes in one school in Surakarta City as a control and experimental class, so it can only be generalized to some schools.

Conclusion

Based on the study results, it can be concluded that there is a significant influence or difference between the experimental and control classes with the application of the Creative problem-solving learning model assisted by Mind Mapping on salt hydrolysis topic. The results of the N-Gain score test showed improved cognitive learning outcomes and creative thinking skills in the experimental class, showing the "high" criterion. In contrast, the control class showed the "medium" criterion. The influence of the Mind Mapping-assisted CPS learning model on creative thinking skills starts from the highest indicators in a row, which are fluency, originality, elaboration, and flexibility. Thus, the CPS learning model assisted by Mind Mapping can be implemented as an alternative learning model for teachers to improve students' cognitive learning outcomes and creative thinking skills which are included in the skills students must master in the 21st century.

Conflict of Interests

The author(s) declares that there is no conflict of interest in this research and manuscript.

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