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Implementation of Creative Problem Solving Model to Improve Students' Critical Thinking Skills in Chemistry Lessons

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Abstract

Implementation of the 2013 and prototype curriculum requires students to master critical thinking skills. This study aims to determine differences improvement of students' critical thinking skills who were taught using Creative Problem Solving (CPS) and direct learning model in chemistry learning. This research is quasi-experimental research. The research sample was 64 student from class 10th grade, which are 32 students in experimental class and 32 students in control class. The sample was taken by purposive sampling. The instrument used is critical thinking skills test consisting of 15 questions. Data collection was carried out pretest and posttest. Data analysis used N-gain test and independent sample t-test. The results showed that the experimental class's average N-gain of critical thinking skills was 0.84 (high) and the control class was 0.61 (medium). There are differences in students' critical thinking skills taught with CPS and direct learning model. The difference in the highest increase is found in the inference indicator which only exists in the CPS learning model. This proves that the application of the CPS model affects critical thinking skills better than the direct learning model.

Keywords: CPS, critical thinking skills, direct learning

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1. Introduction

The 2013 curriculum requires student-centered learning. Learning produces productive, creative, innovative, and affective students through a combination of knowledge, attitudes, and skills (Angkowati, 2020; Astuti et al., 2019). Students required to be able to compete with other countries by mastering the demands of the 21st century, which are creative thinking, critical thinking, communication and collaboration (Chalkiadaki, 2018; Marlina & Jayanti, 2019; Septikasari & Frasandy, 2018). If students do not have 21st century skills, they cannot meet the globalization era's demands and will be difficult to compete in the future (Robi et al., 2018). The results of research by Ridwan et al., (2022) show that learning and innovation skills consist of critical thinking and problem solving, creative and innovative thinking skills, also communication and collaboration. These four skills support the way of thinking and working in order to be able to compete in the future. Currently there is a change in the curriculum, from the 2013 curriculum to

prototype curriculum but the demands for students' critical thinking skills are still the learning objectives.

Critical thinking skills are one of the 21st century skills that need to be optimized (Nuryuliana & Prodjosantoso, 2021). This skill important for science subjects because it is an abstract lesson (Angkowati, 2020). The results of the survey, critical thinking is the leading intellectual skill of the 21st century to improve students' ability in problem solving and decision making (Selman & Jaedun, 2020). Students who have critical thinking skills will solve problems more effectively (Ramadhani, dkk 2021). Critical thinking skills are complex problem solving skills which is important to develop in learning activities to improve students' intelligence (Wahidin & Romli, 2020). Critical thinking skills help students to communicate ideas, analyze, synthesize and evaluate information, provide justification for a wrong information and adapt it to their own knowledge (Saputra et al., 2019; Hamida & Desnita, 2021; Sutama et al., 2022). However, the learning process in Indonesia has many weaknesses in students' thinking skills (Supena et al., 2021). The students's critical thinking skills in Indonesia are still low (Arifin, 2017), as is the human development index ranking in the education sector at 107th out of 188 participating countries. This is also in line with research on students' thinking skills from PISA which shows Indonesia ranks 62 out of 70 countries (OECD, 2019). As research conducted by Irwanto, et al, 2018 shows that the critical thinking skills of students in chemistry learning considered low. Students' critical thinking skills in chemistry lessons are still low in the aspects of analysis, evaluation, explanation, and self-regulation (Utami et al., 2018).

Chemistry lessons are require critical thinking skills because it emphasize the scientific process, in the form of facts, concepts, principles, theories, and laws (Nisa, 2021). The scientific process requires someone to be able to provide responses by using science to solve problems, evaluate ideas, and information in making decisions. Someone who has critical thinking skills is able to analyze information to determine the relevance of the information collected and then disclosed to find a solution to a problem (Mutakinati et al., 2018). Chemistry is a science that studies phenomena and abstract concepts. It requires critical thinking skills to understand chemical concept. Critical thinking In chemistry creates interrelationships information and help student to better understand the specific nature of a certain theory, function, formula, or equation as it pertains to other information (Malinda Wilson, 2015).

Chemistry is one of lessons that difficult for students to understand. It shown from the results of the 2019 national exam, especially in Aceh, chemistry lessons got an average score of 41.69, which considered low. The results of the 2019 national exam material mastery test showed that the material on the basic laws of chemistry was classified as low, which are 37.33 for the indicator of analyzing basic laws based on chemical case; 28.65 for indicators determining the content of compounds; and 23.12 for indicators of determining mass or volume. Students find it difficult to complete national exam questions because a lack of understanding concepts in chemical calculations that use formulas (Asbupel et al., 2021).

The results of the analysis of basic chemical competencies show that the difficulty of stoichiometry is in understanding basic laws of chemistry and calculation of limiting reactions and the concept of moles (Moyo, 2018 ; Lee et al., 2018). The material of the basic laws of chemistry is difficult to understand because it has abstract and concrete characteristics (Hanum et al., 2017). Material that requires students to have skills in writing chemical formulas, writing balanced chemical equations and understanding the concept of moles, molar mass, molar volume, and limiting reactants, but students are still weak in these skills and cause them to be unable to solve basic laws chemistry (Fadillah et al., 2022).

Gas law is a difficult topic for students to understand concepts and problem solving. Putri & Latisma (2022) the results of an analysis of the difficulty of learning the basic laws of chemistry show that students experience the highest difficulty in volume ratio law material (Gay-Lussac's law). This difficulty is because participants must memorize and use chemical formulas incorrectly (Chen et al., 2019). Participants has not been able to develop their skills to understand the basic legal concepts of chemistry to solve chemical calculation problems (Mukhlis & Arusman, 2020). Opara (2014) said that students' critical thinking and problem solving skills on stoichiometric material were still lacking.

The results of the initial observations at SMAN 1 Mutiara showed that the students' chemistry learning outcomes were still categorized as poor, in terms of the average midterm and final semester exam scores of students of 60 and 55 which were still below the minimum completeness criteria score of 70. Results In an interview with a chemistry teacher at SMAN 1 Mutiara, the facts that occur in the field in studying chemical concepts students cannot fully understand the concept and often only memorize so that when the teacher changes the form of the question they are not able to solve the problem. When given high-level questions by the teacher, students cannot complete them. Learners find it difficult to connect concepts and problems; students who have not been proactive in expressing problems in learning, only a few students are involved in answering the problems posed. As a result, students have not been able to provide solutions to the problems found. This condition shows that students' critical thinking skills are still low.

The teacher also explained that in carrying out the teaching and learning process it was still teacher-centered and focused on printed books. The teacher has used the discussion method but that group discussions take place more passively and students are more dominant in listening to information from the teacher so that they do not develop students' critical thinking skills. Based on these problems, teachers must innovate in the teaching and learning process. The learning process can take place more effectively and efficiently by applying learning models, methods or approaches that can increase student creativity. Learning that encourages students to communicate and collaborate in solving problems so that increasing critical thinking skills (Amar et al., 2020; Fitriani et al., 2021). An alternative learning model that can be used is the creative problem solving (CPS) model.

The CPS model emphasizes group work that focuses on learning and problem solving skills (Partayasa et al., 2020). The CPS model is oriented towards finding creative ideas to find the most efficient and effective problem solving by using divergent and convergent thinking processes (Fitriani, 2021). CPS can be defined as a skill to achieve the required goals through creativity in the process of finding new and creative solutions (Suryanto et al., 2020). CPS is a process that provides a framework for planning and developing more effective ways of solving problems using creative thinking skills (Nazzal & Kaufman, 2020). This model consists of four stages, which are clarification of the problem brainstorming, evaluation and selection , also implementation (Sinta, 2020). The CPS process incorporates steps including identifying problems or challenges; generate ideas for possible solutions; solving problems with the help of generated ideas and implementing solution plans (Swaminathan & Rathnasabapathy, 2021).

Research conducted by Kim et al. (2019) related to CPS showed that there was a significant increase in various measures of creativity, creative problem solving, and character. The CPS model is more effective in influencing problem solving abilities than conventional learning (Hobri et al., 2020; Baity, 2021). CPS supports permanent and meaningful learning (Tseng et al., 2013). Learning that uses CPS based worksheets effectively increases student learning

outcomes and creativity because it provides opportunities to discover concepts and construct knowledge independently (Kristanti et al., 2018). CPS can develop students' adaptive reasoning abilities (Ansari et al., 2020). Other research shows that the application of the CPS model can improve learning outcomes (Yuliati & Lestari, 2019; Feriansyah et al., 2021). CPS with open experimental learning can improve students' understanding and students' scientific work (Heliawati et al., 2021). CPS with an inquiry approach is effective for students' science process skills (Sumarli, et al., 2018; Nugroho & Yulianti, 2018). The CPS model carried out in distance or online learning is also able to improve students' critical thinking skills and learning outcomes (Feriansyah et al., 2021; Maharani et al., 2021).

Based on the results of several previous studies, the CPS model can improve learning outcomes and problem solving skills. However, there is still limited research related to the implementation of CPS for critical thinking skills, especially in chemistry subject matter of the basic laws of chemistry. Therefore, this research was conducted to see the difference in improving the critical thinking skills of students who used the CPS model and the direct learning model on the basic laws of chemistry.

2. Research Method

This research was a quantitative research (quasi-experimental method) with a pretest-posttest control group design. This research was conducted at SMAN 1 Mutiara in 10th grade mathematics and natural science 1 (experimental class) and 10th grade mathematics and natural science 2 (control class) each consisted of 32 students. The research sample was taken from 200 population (six classes) of class 10th grade mathematics and natural science students. The sample was selected by purposive sampling based on both classes had the same initial abilities. The research was conducted in two meetings (3x40 minutes each meeting). Experimental class used the CPS model and control class used the direct learning model. Both classes were given an initial test (pretest) and a final test (posttest) to see differences in the improvement of critical thinking skills in the two classes.

The learning tools developed in this study consisted of lesson plans and student work sheets based on the CPS model for the experimental class and direct learning based for the control class. After the lessons plans and student worksheets were developed, they were validated by three validators. The CPS model used in this study has four steps, which are: Clarification; Brainstroming; Evaluation and selection; and Implementation (Sinta, 2020). The direct learning model used in this study has five steps are: orientation; presentation /demonstration; guided practice; checking understanding and provide feedback; and self-training (Aris, 2014).

The instrument used in this study was a test of critical thinking skills consisting of 15 items that had been validated by three experts. The questions were developed based on the critical thinking indicators from Ennis 2011 which are listed in Table 1.

Table 1. Indicators of Critical Thinking Skills

Indicator	Sub Indicator	Question
Basic clarification	1. Focus on a question 2. Analyze arguments 3. Ask and answers to challenging questions	1, 12, 14
Bases for a decision	1. Judge the credibility of a source 2. Observe, and judge observation reports	2,5,8
Inference	1. Deduce, and judge deduction 2. Make material inferences 3. Make and judge value judgments	4, 7, 10
Advanced clarification	1. Define terms and judge definitions 2. Attribute unstated assumptions	6, 9, 13

Indicator	Sub Indicator	Question
Supposition and Integration	1. Suppositional thinking 2. Making and defending a decision	3, 11, 15

Empirical validation of instruments was carried out by testing 30 student in 12th grade who had studied the basic laws of chemistry. The empirical validation results obtained six questions very valid and nine questions valid, the reliability value of instrument was 0.936 (very high).

Data on critical thinking skills collected from the control and experimental classes were analyzed using descriptive statistics. Data on critical thinking skill was tested for normality using Shapiro Wilk and homogeneity test with variance. Furthermore, data that is declared normal and homogeneous will be analyzed using the N-gain test and hypothesis testing using the independent t-test.

3. Result and Discussion

3.1. CPS Model Implementation on The Basic Laws of Chemistry

CPS model was applied for two meetings in the experimental class. The application of the model begins with the teacher providing initial motivation and a brief introduction material to students, then sitting in groups and giving CPS-based worksheets. The obstacles experienced in the application of the CPS model, namely problem clarification at the first meeting students were a little confused when clarifying the problem together by focusing on questions related to Lavoiser's and Proust's laws. Students' difficulties in understanding the implied assumptions of the phenomena presented, the teacher needs to explain and help students to find facts and main issues. The second meeting of students is better at problem clarification. the first meeting of the application of CPS teachers should guide students more in discussions to find new things related to learning material (Bahrudin, 2020). Students are still not able to associate their knowledge with the new problems given (Sisriwati & Syarifuddin, 2019).

In the brainstorming stage students are able to express facts, ideas and solutions related to the basic laws of chemistry in group discussions. Students are very enthusiastic in expressing ideas because at this stage the teacher asks all students to contribute and express ideas freely without questioning right or wrong but still related to the topic. This makes students confident and more courageous in expressing their ideas. This stage makes the biggest contribution in creating an active learning and students centered. Partayasa et al., (2020) showed the results of observations of the CPS model learning activities showed that students actively asked questions and expressed their opinions during discussions and were able to model problems independently. Brainstorming gives students the opportunity to create a large number of ideas. The idea then becomes an alternative in solving problems (Setiawan et al., 2019).

In the selection and evaluation phase, students rediscuss the ideas that have been submitted and then select one by one the truth of the ideas that have been found so that students can find the most appropriate solution. At this stage students stop to think critically in making a decision. This stage is in accordance with one of the indicators of critical thinking skills and has the same explanation, which is choosing a strategy to determine the right solution to solve the problem (Maharani et al., 2021).

The final stage is that students have determined the solution to solve the problems contained in the worksheet and then show the results of the discussion. The use of the CPS model provides opportunities for students to collaborate in solving problems so that all students are active during the learning process. The application of the CPS model can encourage students to be active and recognize errors in thinking so that they can develop thinking power to solve a problem (Dewi & Putra, 2020).

3.2. Analysis of Differences in Critical Thinking Skills Improvement

The critical thinking skills of students in this study were measured using essay questions that were suitable for use after content validation and empirical validation, totaling 15 items. The results of the analysis of students' critical thinking skills is shown in Table 2.

Table 2. Analysis of Critical Thinking Skills

Class	Average Critical Thinking Skills		N-gain	Category
	Pretest	Posttest		
Experiment	26.56	88.47	0.84	High
Control	24.58	58.43	0.61	Medium

The results of students' critical thinking skills are in Table 2 shows that the pretest mean score of the experimental and control classes is relatively the same and classified as very low with the acquisition of an average pretest score of 26.56 for the experimental class and 24.58 for the control class. This illustrates that the initial ability of students in the material of the basic laws of chemistry is still very low. The mean posttest of students after being given treatment was 88.47 in the experimental class with the high category and 58.43 in the control class which was classified as less. The improvement of students' critical thinking skills for both classes was analyzed through the acquisition of N-gain scores. The results showed that the N-gain score of the experimental class was better than the control class, which was 0.84 (high) in experimental class, while 0.61 (medium) in the control class. During the process of implementing CPS model and direct learning there are differences between the two, students who learn with direct learning are more passive in analyzing problems because students wait for the teacher to give an explanation while students who learn with CPS are more active, because students are required to understand the problem then find a solution by discussing. This provides an opportunity for students to develop their thinking skills. Students who learn to solve problems will make them apply their knowledge to discover new knowledge (Carbogim et al., 2017). Problem-based learning makes students integrate knowledge on an ongoing basis in relevant contexts so that they can improve critical thinking skills (Puspita & Aloysius, 2019). Then tested the hypothesis to see the difference critical thinking skill improvement both class. hypothesis testing using independent sample t-test with a significance level of 5%. The results of the analysis are summarized in Table 3.

Table 3. Hypothesis Test of Student's Critical Thinking Skills

Class	Average N-gain	t-test	
		t_{count}	t_{table}
Experiment	0.84	6.297	1.997
Control	0.61		

Critical thinking skills data before being tested hypotess first carried out a prerequisite test, which are the normality test and homogeneous test. The results of the normality test analysis showed that all experimental and control group data at the pretest and posttest were normally distributed with a significance value of Shapiro-Wilk > 0.05. The homogeneity test analysis of the two classes also showed a significant value with a pretest of 0.721 > 0.05 and a posttest of 0.083 > 0.05, so it can be concluded that the data is homogeneous. Then, the independent sample t-test was tested using the SPSS software version 20.0 with a significant value > 0.05 . The results of testing the hypothesis show that t_{count} is greater than t_{table} with the acquisition of t_{count} (6.297) > t_{table} (1.997) then accept Ha reject H0 so it can be concluded that there is a significant difference in increasing critical thinking skills between the two classes. The thing that affects the differences in the improvement of the two classes' critical thinking skills is the difference in the learning process. The learning experiment class was carried out by implementing the CPS model while the learning control class was carried out by applying direct learning. There is a difference in increasing critical thinking skills between students who are given the CPS learning model and students who are given the direct learning model besides that

student activities are classified as active as long as the CPS learning model is applied (Wahyuni et al., 2018). In accordance with the results of Angkowati's research shows that the application of the CPS model can improve students' critical thinking skills, support the habituation of 21st century skills in students (Angkowati, 2020). CPS is a learning model that emphasizes critical thinking skills in solving problems, providing opportunities for students to choose solutions and develop ideas for problem solving (Sari et al., 2019). The description of the pretest and posttest score of critical thinking skills for each indicator of the two classes can be seen in Figure 1 and the N-gain every indicator of the two classes is shown in Figure 2.

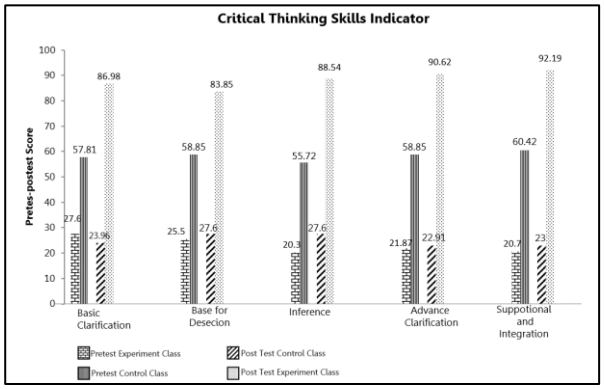

Figure 1. Pretest-Posttest Scores Critical Thinking Skills Indicator of Experimental and Control Class

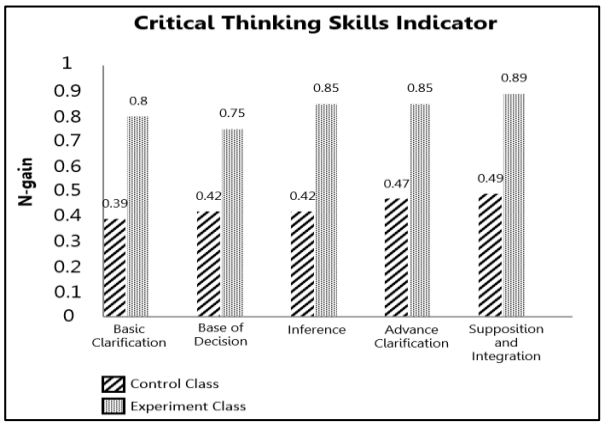

Figure 2. N-gain Critical Thinking Skills Indicator of Experimental Class and Control Class

Based on Figure 1, the pretest score each indicator for the two classes is relatively same and still low. After treatment the experimental class obtained better posttest scores than the control class, so there was difference in the improvement of the two classes for each indicator as shown in Figure 2. The experimental class of the five indicators increased in the high category and the control class in the medium category. Critical thinking indicators that experienced the highest increase in the two classes were supposition and integration indicators, while the indicators that experienced the highest difference in the two classes were inference. This is influenced by the application of different learning models. The steps of the CPS model as a whole provide opportunities for students to think critically. The problem clarification stage of students is able to understand the problem in detail, making it easier for students to understand the main problem of a topic (Effendi & Fatimah, 2019). The second stage of brainstorming students solve problems by finding various alternative ideas or ideas, to find a solution in the form of the most efficient solution to a problem using a thinking and convergent process (Sari et al., 2019) (Setiawan et al., 2019). In contrast to the control class which uses the direct learning model, students are not familiar with the process of understanding problems because students who use this model obtain information from the teacher without finding problems themselves. The direct learning model does not emphasize student-centered learning. Students experience limitations to move and express. Teachers have strong control over learning so that students do not have the power to develop thinking skills (Fauziah et al., 2020). During the learning process using the CPS model, students are trained to develop critical thinking to help solve problems both individually and in groups (Agustini et al., 2020).

3.2.1. Basic clarification

The first critical thinking skill indicator is the ability to provide basic/simple explanations. In this skill there are three aspects: focus on a question; analyze arguments; ask and answers to challenging questions. The results

of developing critical thinking skills include three questions to measure this indicator, which are question number 14 (focusing on the question); number 12 (analyzing arguments) and number 1 (asking questions and answers to challenging questions through a problem solving process). The pretest score of the control class and the experimental class on this indicator showed the same are 27.6. Students are still having difficulties due to limited knowledge about the content presented. After the learning process, there were differences in grades in the two classes. The experimental class is 86.98 higher and the control class is 57.81. This shows that there is a difference in N-gain in the control class of 0.39 (medium) and 0.80 (high) in the experimental class. The distribution of the number of students answering critical thinking skills questions for each aspect of this indicators are shown in Table 4 and Table 5.

Table 4. The Number of Students in The Experimental Class Who Answered The Questions of Basic Clarification Aspects

	Aspect	Experiment Class					
		Score					
		Pretest			Posttest		
		2	1	0	2	1	0
1.	Focus on a question	5	7	19	31	0	1
2.	Analyze arguments	6	7	19	25	3	4
3.	Ask and answers to challenging questions	2	4	26	23	5	3

Table 5. The Number of Control Class Students Who Answered The Questions of Basic Clarification Aspects

	Aspect	Control class					
		Score					
		Pretest			Posttest		
		2	1	0	2	1	0
1.	Focus on a question	8	10	14	29	2	1
2.	Analyze arguments	4	0	22	8	8	16
3.	Ask and answers to challenging questions	3	3	26	11	7	11

The distribution of the number of students in Tables 4 and 5 shows that the aspect of focusing on the question of improving the skills of students in the control and experimental classes is relatively the same, while the aspect of argument analysis differs greatly in the improvement of the experimental class with the control class. The results of the posttest control class were only eight students who were able to answer correctly in analyzing the arguments while the experimental class had 25 students who answered all the concepts correctly. There are also differences in the aspect of answering challenging questions for the two classes. The class that used the CPS model initially answered correctly only two students increased to 23 students. The class using the direct learning model increased form 3 to 11 students who answered correctly.

Different learning models lead to differences in improving students' abilities in aspects of argument analysis and answering challenging questions. The first step of the CPS model is clarification of the problem, students are guided to observe and find problems in student worksheets by focusing on questions related to these problems. Students must analyze the problem so that it makes it easier for students to provide a basic explanation of the phenomenon of the basic laws of chemistry. This is in line with the research of Amar et al., (2020) which revealed that the use of CPS in learning allows students to be active in clarifying problems and facilitating students in expressing ideas and solutions. During the process of discussing the problems contained in the worksheet, students can develop ideas and ask questions that can improve critical thinking skills (Karyadi et al., 2020) .The process of identifying and understanding problems can lead to learners for critical thinking (Mahanal et al., 2019).

3.2.2. Bases for a Decision

Bases for a decision students are required to be able to judge the credibility of a source; observe and judge observation reports. To measure this indicator there are three questions, which are questions number two

and number five for aspects of observe and judge observation reports and question number eight to judge the credibility of a source. The achievement of students' critical thinking skills on the indicators of bases for a decision experimental class obtained N-gain of 0.75 (high) while the control class was 0.42 (medium). The distribution of the number of students answering critical thinking skills questions for each aspect of this indicators are shown in Table 6 and Table 7.

Table 6. The Number of Experimental Class Students Who Answered The Questions of Bases for a Decision Aspects

Aspect	Experiment Class					
	Score					
	Pretest			Posttest		
	2	1	0	2	1	0
1. Observe and judge observation reports	4	20	8	25	7	0
2. Judge the credibility of a source	2	5	25	22	6	0

Table 7. The Number of Control Class Students Who Answered The Questions of Bases for a Decision Aspects

Aspect	Control Class					
	Score					
	Pretest			Posttest		
	2	1	0	2	1	0
1. Observe and judge observation reports	3	22	7	12	14	6
2. Judge the credibility of a source	3	3	26	14	6	12

The scores of students answering this indicator in Tables 6 and 7 show the aspects of observe and judge observation reports of the experimental class and control class pretest are equal, after being given treatment there are significant differences. The experimental class had 25 students answered correctly while the control class had only 12 students answered correctly. The second aspect is Judge the credibility of a source, at first the experimental and control class contained 25 and 26 students did not answer. The results of the posttest experimental class were 22 students answered correctly and there were 14 students answered correctly in the control class.

The implementation of CPS is better in base decision skills of students compared to the direct learning model. Indicators of base decision in the experimental class are trained through the CPS model where in the first step students are given a problem related to the basic laws of chemistry, then focus on finding solutions through group discussions. Furthermore, at the stage of expressing opinions, students are asked to consider experimental data and phenomena related to the basic laws of chemistry and determine their suitability with the concepts of each law in the worksheet. At this stage, students are given the freedom to express their opinions about how to solve problems. This spurs students to better understand concepts, thus helping students to develop critical thinking skills. In line with the research results of Fahrisa & Parmin (2022) that learning using the CPS model is effective for improving students' critical thinking skills. CPS provides a memorable learning experience for students and guides students to be active and strengthen their memory in finding solutions to problems independently by understanding the concept as a whole so as to improve students' thinking skills (Eriyanti & Suryanti, 2018).

3.2.3. Inference

The third critical thinking skill is the ability to inference. One aspect of it is deduce and judge deduction. The questions to inference skill are question numbers four, ten, and seven. Improving students' critical thinking skills on this indicator is obtained a score for the experimental class is 0.85 (high) while the control class is 0.42 (medium). The improvement of the three aspects resulted in the experimental class are better than the control class. The distribution of the number of students answering the indicator questions inference is in Table 9 and Table 9.

Table 8. The Number of Experimental Class Students Who Answered The Questions of Inference Aspects

	Aspect	Experiment Class					
		Score					
		Pretest			Posttest		
		2	1	0	2	1	0
1.	Deduce and judge deductions	3	5	24	26	6	0
2.	Make material inferences	7	6	19	28	3	16
3.	Make and judge value judgments	6	10	16	24	7	1

Table 9. The Number of Control Class Students Who Answered The Questions of Inference Aspects

	Aspect	Experiment Class					
		Score					
		Pretest			Posttest		
		2	1	0	2	1	0
1.	Deduce, and judge deduction	3	3	26	13	17	12
2.	Make material inferences	3	4	25	16	7	9
3.	Make and judge value judgments	8	4	20	9	13	10

The distribution of the number of students answering the aspect of inference by deduction and assessing it in Table 8 and 9 shows that in this indicator the initial abilities of two classes are equal. The implementation of the CPS model improved the inference skills by deduce and judge deduction in the experimental class significantly increased from 3 people to 26 people who were able to answer the questions correctly and all were completed, while in the control class only 13 students answered correctly and 12 students did not answer. This shows that in the control class there are still many who are not able to make deductive conclusions. The aspect of make material inferences of the experimental class increased from 7 students to 28 students who answered correctly. The control class also increased from 3 to 16 students who answered correctly. In this aspect the control class is better than the aspect of making conclusions by deduction. Aspects of make and judge value judgments there is a significant difference between the control and experimental classes. The experimental class test results were initially 6 students who were able to answer correctly increased to 24 students, while the control class test results were initially 8 students who answered correctly to nine students. In the inference indicators, the test results of the experimental class and control class look very different in the aspect of make and judge value judgments.

The difference between the improvement in the control class and the experimental class is because in the control class, students have not been trained to conclude a phenomenon related to the concept of the basic laws of chemistry. During the learning process students hear and memorize the concepts conveyed by the teacher. In contrast to the experimental class, at the evaluation and selection stage, students independently make a conclusion based on the results of the discussion at the problem clarification stage and opinion expression by selecting the right and effective solution to work on the questions on the student worksheets. Simarmata (2022) said that CPS is a learning process that focuses not only on acquiring as much knowledge as possible but also on how to use all existing knowledge to solve certain problems. Erdogan (2019) Someone who is trained by solving problems will be able to make decisions because they are able to understand how to collect relevant information, analyze and reevaluate. A person's critical thinking skills can develop through problem solving by expressing the reasons so that they can find the right solution (Wiranti & Sitompul, 2022) .

3.2.4. Advanced Clarification

Advanced clarification indicator consisting of two aspects are define terms and judge definitions, attribute unstated assumptions. Further explanation is skill-oriented to consider the definition according to the criteria based on the assumptions that have

been identified (Afriana et al., 2021). To measure this skill, it is found in questions number 9 and 13. Problem number nine students must provide further explanation regarding the relationship between the phenomenon of compound formation and Dalton's law concept. In this problem, students can explain in detail and clearly the relationship between the formation of compounds according to the definition of Dalton's law. Problem number 13 students must relate the assumptions implied in the experimental data presented to prove one of the basic laws of chemistry (Avogadro's hypothesis and explain in detail). The increasing value of this indicator for the experimental class is 0.85 (high) and 0.47 (medium) for the control class. The number of students who answered this aspect are shown in Tables 10 and 11.

Table 10. The Number of Experimental Class Students Who Answered The Questions of Advanced Clarification

Aspect		Experiment Class					
		Score					
		Pretest			Posttest		
		2	1	0	2	1	0
1.	Define terms and judge definitions	6	6	20	27	2	3
2.	Attribute unstated assumptions	0	7	25	30	2	0

Table 11. The Number of Control Class Students Who Answered The Questions of Advanced Clarification Aspects

Aspect		Experiment Class					
		Score					
		Pretest			Posttest		
		2	1	0	2	1	0
1.	Define terms and judge definitions	5	2	25	4	18	10
2.	Attribute unstated assumptions	1	9	22	11	14	7

Tables 10 and 11 shows the aspects of define and judge definitions terms in the experimental and control classes, the pretest scores are equal. After being given treatment there was a significant difference. The experimental class had 27 students answered correctly while the control class had no significant increase (only five students). Attribute unstated assumptions aspect also shows that there is a difference in improvement in the two classes. The experimental class initially did not get anything right, it increased to 30 students answered correctly. In contrast to the control class, at first there was one student who answered correctly, increasing to 11 students. This shows that the implementation of CPS is better in building skills to advanced clarification compared to the direct learning model. Through CPS learning, especially at the selection and evaluation stages, one must be able to understand the implied assumptions of the problem so that they can choose the right solution. Furthermore, at the implementation stage, students are trained to provide further explanations regarding the disclosure of solutions in solving problems in worksheet, besides that students must provide detailed and easy-to-understand explanations to classmates when presenting the results of group discussions (Nurdin et al., 2020).

3.2.5. Supposition and Integration

Supposition and Integration consists of two aspects, are suppositional thinking, making and defending a decision. To measure this skill, there are questions number 3, 11 and 15. Problem number three students must make and design the right steps to do Lavoiser's law proof practicum. Problem 11 students are asked to make a decision on a reaction that produces the most volume and explain it to defend the decision. Problem number 15 students are asked to make a decision from an experimental result in accordance with one of the concepts of the basic laws of chemistry. The increasing value of this indicator for the experimental class is 0.89 (high) and 0.49 (medium) for the control class. This indicator experienced the highest increase of all indicators of critical thinking skills. In this indicator, students have very low pretest scores but high posttest scores. Initially, students have not been able to think predictively and defend their decisions on a

given problem. Lack of knowledge makes it difficult for students to make decisions and design the right solutions. After learning students already have complete knowledge and dare to make a decision in solving the problem. The experimental class is higher because during the learning process students search for information independently so that they understand the relevant concepts for the right solution. This makes students more trained to give and maintain the right decisions. Problem-based learning is not only about problems but also on understanding relevant concepts so as to facilitate students developing critical thinking (Aini et al., 2019). Someone who thinks critically can differentiate, analyze information and is able to take responsibility for his decisions according to context (Basri et al., 2019).The increase in this indicator can be seen in the number of students who scored for each aspect in Tables 12 and 13.

Table 12. The Number of Students in The Experimental Class Who Answered The Questions of Supposition and Integration Aspects

	Aspect	Experiment Class					
		Score					
		Pretest			Posttest		
		2	1	0	2	1	0
1.	Supposition al thinking	13	10	9	29	3	0
2.	Making and defending a decision	1	7	24	29	3	0

Table 13. The Number of Control Class Students Who Answered The Questions of Supposition and Integration Aspects

	Aspect	Experiment Class					
		Score					
		Pretest			Posttest		
		2	1	0	2	1	0
1.	Suppositional thinking	9	6	17	24	6	2
2.	Making and defending a decision	0	11	21	5	24	3

Based on Tables 12 and 13, there is no significant difference between the uppositional thinking aspect of the experimental class and the control class, because the questions to measure this aspect asking the student to predict the appropriate steps to design a practicum, which is more of a memorization of concepts. The second aspect is making and defending a decision. In this aspect there is a big difference in improvement in the two classes. At first the experimental class who answered correctly only one person increased to 29 students who answered correctly. The results of the control class test at first did not answer correctly, 11 people answered half correctly and 21 did not answer, after treatment only five people answered correctly, 24 answered half correctly and did not answer.

The difference in the improvement of supposition and integrationskills due to learning using CPS at the selection and evaluation stages provides an opportunity for students to be able to predict the right solution in problem solving by making decisions and defending their decisions. During the learning process students are not only asked to express ideas but also have to decide and choose an idea with relevant reasons to judge the best choice. The CPS model has a good impact on student learning activities, fostering student initiative in learning so that students can develop critical thinking skills to make a problem solving (Wiranti & Sitompul, 2022). The CPS model is effective in improving higher-order thinking skills, students are more skilled in connecting information and making decisions (Adila et al., 2020).

4. Conclusion

Based on the results of the study it can be concluded that there are differences in the improvement of students' thinking skills taught by the CPS and direct learning model. There are differences in the increase in critical thinking skills for each indicator, the experimental class is in the high category and the control class is in the medium category.

The difference in the highest increase is found in the inference indicator, because CPS provides opportunities for students to independently make decisions. The implementation of the CPS model affects critical thinking skills better than the direct learning model.

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