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Effectiveness of the Conceptual Understanding Procedures (CUPS) Learning Model on Students' Higher-Order Thinking Skills in Basic Chemical Law Material

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Abstract

Students' higher-order thinking skills in chemistry remain low due to the dominance of conventional teaching methods. This study aimed to investigate the effect of the CUPS (Conceptual Understanding Procedures) learning model on students' higher-order thinking skills in the topic of basic laws of chemistry. Using a quasi-experimental design with a pretest-posttest control group, two classes of 28 students each from SMAN 1 Suwawa were selected as the experimental (CUPS-based learning) and control (conventional learning) groups. Data were analyzed using independent sample t-test. Results showed a greater improvement in the experimental class (pretest = 61, posttest = 79) compared to the control class (pretest = 39, posttest = 64). A significant difference was found between the groups ($p = 0.001 < 0.05$), leading to the rejection of the null hypothesis. These findings indicate that the CUPS learning model positively enhances students' higher-order thinking skills, suggesting its potential for improving chemistry education.

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1. INTRODUCTION

Chemistry is a branch of science taught at the high school level and plays a crucial role in developing students' scientific thinking skills. In addition to studying substances and their reactions, chemistry also teaches an understanding of natural phenomena through abstract and complex concepts. Therefore, learning chemistry demands in-depth understanding and higher-order thinking skills. However, in practice, many students find chemistry a difficult and confusing subject, necessitating appropriate learning strategies to help them grasp the material more effectively.

At the 10th grade of high school, chemistry is introduced in greater depth than at the junior high school level, where chemistry is generally presented in science lessons. High school chemistry requires students to systematically link concepts to prepare them for understanding more complex chemistry at the next level. One of the fundamental concepts that forms an important foundation is the basic laws of chemistry. This material is closely related to advanced concepts such as the law of conservation of mass, the law of definite proportions, the law of multiple proportions, and the concepts of moles and stoichiometry. The material necessitates not only a deep conceptual understanding but also proficiency in analytical thinking and mathematical competence.

The basic laws of chemistry require higher-order thinking skills (HOTS), as students must be able to analyze relationships between laws, apply concepts in various contexts, and draw logical conclusions. According to Anderson and Krathwohl's revised Bloom's Taxonomy, higher-order thinking skills encompass the three highest cognitive levels: analyzing (C4), evaluating (C5), and creating (C6) (Prayitno & Nofiana, 2021). If students lack

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adequate higher-order thinking skills, they will struggle to grasp the concepts of basic laws of chemistry in depth, ultimately resulting in poor learning outcomes and low student motivation.

Observations and interviews at SMAN 1 Suwawa indicate that students experience difficulties in understanding the basic laws of chemistry. Learning is still dominated by lectures and note-taking, without engaging students in learning activities that encourage active engagement, critical thinking, or problem-solving. Students tend to be passive, rarely ask questions, and struggle to answer questions that require analysis or application of concepts in real-life contexts. Chemistry teachers also reported that students are not yet accustomed to working on problems that require logical reasoning, such as comparing the mass of substances before and after a reaction based on Lavoisier's Law. Furthermore, learning activities involving simple experiments or projects are rarely conducted. This aligns with the findings of Wahab and Rosnawati (2021) that low student interest and learning outcomes in chemistry are influenced by a lack of variety in learning methods as well as a lack of direct learning experiences and meaningful discussions in class.

To address these issues, a learning approach is needed that encourages the development of HOTS and active student engagement. Widana (2017) states that HOTS can be developed through three methods: an effective learning process, a literacy movement, and the creation of HOTS questions. One learning model specifically designed to improve conceptual understanding and higher-order thinking skills is the Conceptual Understanding Procedures (CUPS) model. The CUPS model involves systematic stages such as concept identification, procedure analysis, and application of concepts in various contextual situations. This model directs students to construct their own concepts, draw conclusions in their own words, and learn actively, so that understanding becomes more meaningful and lasting (Pancawani et al., 2023).

The CUPS model is based on a constructivist approach, which emphasizes that students construct knowledge through active learning experiences and interactions with their environment. This approach promotes the development of critical, creative, and collaborative thinking skills in addressing problems (Agung & Ardiansyah, 2023). Therefore, implementing the CUPS learning model is believed to help students develop HOTS (Highest Level of Intelligence) and better understand the concepts of basic chemical laws.

The concept of Higher Order Thinking Skills (HOTS) was first introduced by Brookhart. He explained that learning involving HOTS encourages students to tackle tasks or questions that are new to them, thereby stimulating deeper and more complex thinking processes (Ali, 2019).

Thomas and Thorne describe HOTS as a thinking activity that goes beyond merely recalling or repeating information. They emphasize that HOTS involves deeper reasoning than simply applying formulas or procedural steps. This view is supported by Onosko and Newman, who state that HOTS is non-algorithmic, as students are challenged to solve new problems they have never encountered before (Nugroho et al., 2024).

Higher-order thinking skills play a crucial role in the learning process as they are directly related to how students process and understand information in depth. These abilities influence the effectiveness, quality, and speed of one's learning. Therefore, learning activities designed to foster students' thinking skills will have a positive impact on their educational outcomes (Yee Mei Heong et al., 2011).

The Conceptual Understanding Procedures (CUPs) learning model was first introduced by Mills and Feteris in 1996 and was later refined by Mulhall and McKittrick in 1999, 2001, and 2007 (Putri, 2019). This model is an extension of cooperative learning, designed to help students grasp difficult concepts through active and collaborative learning activities (Ardianti, 2020; Pratiwi et al., 2014).

The CUPs model is grounded in a constructivist approach, which emphasizes that conceptual understanding is developed by modifying and expanding prior knowledge (Sururuddin, M. 2015). In its implementation, students are divided into small heterogeneous groups and encouraged to actively express their opinions, construct knowledge independently, and exchange ideas with one another (Gita et al., 2018).

According to Gunstone (in Nurfaqihah et al., 2023), the Conceptual Understanding Procedures (CUPs) model consists of four main stages, namely;

1. Students are asked to solve a problem individually.

2. Students are divided into small, heterogeneous groups (2-4 people) to discuss a common problem. The teacher acts as a facilitator, observing the discussion without much intervention.
3. Each group re-examined the problem through in-depth discussions (triplet discussions).
4. The results of the group discussions are presented in a class discussion. During this stage, students compare various answers and develop arguments until a consensus is reached. The teacher only provides explanations after students have actively engaged in their thinking and participating in the discussion.

The stages of CUPs are designed to guide students in building conceptual understanding gradually and improving thinking and problem-solving skills (Saregar, Latifah, & Sari, 2016; Anwar et al., 2023).

The Conceptual Understanding Procedures (CUPs) learning model has several advantages and disadvantages. Its main advantage is that it provides equal opportunities for all students, whether low, medium, or high ability, to develop. This model also encourages active student involvement in learning, strengthens conceptual understanding, and stimulates critical thinking and teamwork (Hidayati in Leonardo et al., 2023). However, this model's weaknesses include requiring considerable preparation time and strict time management at each stage. Group or class discussions can potentially be dominated by more active and confident students, while shyer students or those with lower academic abilities can be marginalized. To address this, teachers need to facilitate the involvement of all students, including directly guiding less active students to participate in discussions (Yulianti et al., 2020).

2. METHOD

This research was conducted at SMA Negeri 1 Suwawa, located on Jalan Pasar Minggu, Tingkohubu, Suwawa District, Bone Bolango Regency, during the 2024/2025 academic year. The research period was approximately 2 months, from April 2025 to May 2025.

This study used a quasi-experimental method with a pretest-posttest control group design. In this design, both the experimental and control groups were given pretests and posttests. Prior to treatment, students from both groups underwent a pretest to measure their initial abilities. The experimental group was taught using the Conceptual Understanding Procedures (CUPs) model, while the control group used a conventional learning model. The research design is presented in Table 1.

Table 1. Research Design

Class	Pretest	Treatment	Posttest
Experiment	O1	CUPs Model	O2
Control	O1	Conventional	O2

Source: (Sugiyono, 2020)

The population in this study was all students of class XD and XE of SMAN 1 Suwawa in the even semester, totaling 56 people. Because the population is relatively small, The study employed a saturated sampling technique, in which all members of the population were included as the sample. Class XD was designated as the experimental class and class XE as the control class, each consisting of 28 students.

The data collection technique in this study was conducted through a pre-test and post-test using a descriptive test instrument that measures critical thinking skills. This instrument was developed based on five aspects of critical thinking: providing simple explanations, building basic skills, concluding, providing further explanations, and strategies and tactics. In addition, data was also collected through initial and final observations to measure collaboration skills using an observation sheet, which was compiled based on five indicators: cooperation, responsibility, communication, flexibility, and compromise.

Data analysis techniques include: test validity test, test reliability test, data normality test, homogeneity test, to test the hypothesis with the independent sample t-test, and the paired sample t-test.

3. RESULT ANDDISCUSSION

3.1. Result

This study's data consisted of pre-test and post-test scores. initial and final observation results, prerequisite test results, and hypothesis test results.

Pre-test and Post-test Results of Higher-Order Thinking Skills

The average results of the pre-test and post-test of high-level thinking skills in the experimental class and the control class can be presented in Table 2 below.

Table 2. Pre-test and Post-test Results of Higher-Order Thinking Skills in the Control Class and Experimental Class

Class	Average value (%)	
	Pre-test	Post-test
Control	39	64
Experiment	61	79

Table 2 shows that both the control and experimental classes experienced an increase in average scores from pre-test to post-test. The control class's score increased from 58 to 77, while the experimental class's score increased from 56 to 81. The increase was greater in the experimental class using the CUPS (Conceptual Understanding Procedures) learning model.

Prerequisite Test Results

The following presents the results of the prerequisite tests that have been carried out by researchers.

1) Normality Test

Normality testing was conducted using the Shapiro–Wilk method in SPSS version 29 to evaluate whether the data followed a normal distribution. Data are considered normal if the p-value exceeds 0.05, and non-normal if the p-value is below 0.05.The results of the pretest and posttest normality tests conducted by the researchers in the experimental and control classes are presented in Table 3 below:

Table 3. Results of Normality Testing of High-Order Thinking Skills

Class	Shapiro Wilk		
	Statistics	df	sig
Pre-test Control	0.965	28	0.457
Post-test Control	0.978	28	0.798
Experiment Pre-test	0.054	28	0.255
Post-test Experiment	0.954	28	0.438

Based on Table 3 Referring to the results in the Table, the significance data of the pre-test and post-test of critical thinking skills in the control class and the experimental class is > 0.05 so it can be concluded that the pre-test and post-test data obtained are normally distributed.

2) Homogeneity Test

The homogeneity test was carried out to verify that the variance of data between the experimental and control classes was consistent. The test used Levene's Statistics in SPSS version 29, with the results shown in the following table:

Table 4. Results of Homogeneity Test of High-Order Thinking Ability.

Mark	Levene Statistics	df1	df2
Pretest	0.069	1	0.915
Posts	3,442	1	0.069

Based on Table 4, the significance data for the pre-test and post-test in the control class and the experimental class were > 0.05, so it can be concluded that the pre-test and post-test data obtained were homogeneous.

Hypothesis Testing Results

After testing for normality and homogeneity, the data were found to be normally distributed and homogeneous. The next step was to test the hypothesis using a t-test. This test will determine the validity of the research results, allowing for acceptance or rejection of the research hypothesis. This test includes the Paired-Samples t-test and Independent-Samples t-test, as presented in Table 5.

TestHypothesis

Table 5. Results of the t-Test for High-Order Thinking Skills

No	Paired-Samples t-test		
	H0 Test Criteria	Test Results	Decision
1	H0 is rejectedif sig value < 0.05	Sig value =0.001	H0 is rejected, there is significant difference between pre-test and post-test scores of students in the experimental class
	Independent-Samples t-test		
	Test Criteria	Test Results	Decision
2	H0 is rejectedif the sig value < 0.05	Sig value = 0.001	H0 is rejected, there is an influence of the CUPs learning model on high-level thinking skills in the material on basic chemical laws.

3.2. Discussion

This study aims to analyze the effect of applying the CUPS (Conceptual Understanding Procedures) learning model on students' high-level thinking skills in the Basic Laws of Chemistry material.

The application of the Conceptual Understanding Procedures (CUPs) model in chemistry learning has been shown to significantly improve students' higher-order thinking skills, particularly when studying The Basic Laws of Chemistry. Through the learning design of this model, students are guided not merely to memorize concepts but to gain a more profound understanding of the material. This is evident in the difference in final test results between the two groups of students. Students who participated in the CUPs model achieved an average score of 79.4, while students in the class taught using conventional methods only achieved an average of 64.4. This difference in scores reflects an increase in understanding and better thinking skills in students who were actively involved in the CUPs process.

Furthermore, statistical test results indicate that this difference did not occur by chance. Hypothesis testing using a t-test yielded a significance value of 0.001, which is significantly lower than the 0.05 confidence level generally used in research. This means that, statistically, students learning using the CUPs model did indeed show significantly greater development in higher-order thinking skills compared to those learning conventionally.

The CUPs model provides space for students to think independently first, then exchange ideas in groups, discuss ideas in depth, and finally share their findings with the class. The teacher does not directly explain, but rather gives students the opportunity to construct their own understanding through discussion and reflection. In this way, students not only better understand the material but also learn to express their opinions, listen to their peers' ideas, and draw conclusions together. This makes the learning process more lively and meaningful. This success demonstrates that an approach that encourages active engagement and in-depth understanding is far more effective than one-way teaching methods that only emphasize the delivery of information. This finding is also supported by various previous research results. For example, research by Pancawani et al. (2023) suggests that the implementation of the CUPs model encourages students to think critically through structured and reflective discussion stages. Furthermore, Agung and Ardiansyah (2023) found that CUPs can improve students' analytical and problem-solving skills because students are given space to think independently, then enrich their understanding through group discussions. In this research, the teacher's role is not merely as a transmitter of information, but also as a facilitator, guiding students' thinking processes to maintain a scientific and logical path. This aligns with the student-centered learning approach, which emphasizes the need for students to actively construct their own understanding through meaningful learning experiences.

One of the strengths of the CUPs model lies in its learning steps, which balance individual and collaborative thinking processes. In the first stage, students are asked to solve a problem individually. This stage is crucial for building students' initial thinking and activating their prior knowledge. In this process, students learn to rely on their own logic, strive to understand the problem, and formulate solutions based on their initial understanding. Although some students may appear hesitant at first, they gradually become accustomed to using reason and not immediately relying on the teacher's explanations. This is a good start to fostering independence in learning.

The next step is to form small, heterogeneous groups of three to four students to discuss a common problem. These group discussions provide a space for students to exchange opinions, listen to one another, and clarify their thoughts. This process serves as a social learning platform that not only strengthens conceptual understanding but also fosters empathy and respect for differing perspectives. The teacher simply observes the discussion and does not immediately provide answers, which strengthens the students' position as active learners.

Afterward, the groups proceed to the in-depth discussion stage, or triplet discussion. This stage provides a space for students to truly delve into the problem at hand, re-examine the arguments they have constructed, and explore the connections between relevant chemical concepts. In a limited group setting, students tend to be more open in expressing ideas and dare to express confusion or new thoughts. This process gradually encourages students to not only memorize concepts but also understand their essence and be able to apply them in new situations. Widana (2017) emphasized that higher-order thinking skills do not emerge instantly, but are developed through a systematic process, one of which is in-depth discussion activities that provide space for reflection.

The fourth stage is the culmination of the learning activity, namely the presentation of discussion results in a class forum. In this stage, students are given the opportunity to express their group's ideas, listen to the views of other groups, and compare various problem-solving strategies. Class discussions not only provide a forum for sharing solutions but also a forum for validating arguments, which fosters scientific communication skills. This process teaches students to boldly express ideas, politely challenge them, and accept criticism openly. Only after the discussion has led to a shared conclusion does the teacher provide an explanation that strengthens students' understanding. This approach ensures that students have gone through a deep cognitive process before receiving confirmation from the teacher. Wahab and Rosnawati (2021) stated that learning that allows for exploration and active engagement like this is more effective in enhancing conceptual understanding and HOTS than traditional lecture methods.

When examined as a whole, the CUPs model is not only effective in improving students' cognitive aspects but also in developing scientific attitudes such as openness, collaboration, and curiosity. Another strength of this model is its flexibility in being applied to various chemistry topics, both conceptual and applied. CUPs teach students not only to seek answers but also to understand the thought process leading to those answers. In this way, students learn to value the process, not just the results.

Thus, the application of the CUPs model in learning the Basic Laws of Chemistry provides a comprehensive learning experience: from individual to collaborative thinking. All these processes occur in a series of interconnected and mutually reinforcing processes. Therefore, this model is highly recommended for broader application in chemistry learning and other subjects requiring in-depth understanding and higher-order thinking skills.

4. CONCLUSION

Based on the research results and discussion, it can be concluded that there is a significant influence of the application of the CUPs model on students' higher-order thinking skills in the material on basic chemical laws. This is proven by the results of the independent t-test analysis which showed a significance value (Sig. 2-tailed) of 0.001 (<0.05). The average post-test score of students in the experimental class was 79.4, higher than the control class which was only 64.4.

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