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Enhancing Cognitive and Communication Skills in Learning Chemistry through Case-Based Learning Integrated with Question and Answer and Whole-Class Discussion Methods

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Abstract: The objective of this study is to assess the efficacy of a Case-Based Learning (CBL) model integrated with a question-and-answer method and class discussion in enhancing students' cognitive and communication skills. The research employed a one-group pretest-posttest experimental design. The subjects of the study were third-semester students enrolled in an inorganic chemistry 1. Intially, students were assessed through a pretest designed to measure their cognitive and communication skills. After implementation of the CBL model, followed by question-and-answer sessions and class discussion, a posttest was conducted to evaluate improvements in these skills. The results demonstrated significant enhancement in students' cognitive and communication abilities. The CBL model encouraged students actively analyze authentic cases and articulate logical solutions, thereby strengthening their critical thinking and oral communication skills. Based on these findings, it can be concluded that the model is medium effective in enhancing the quality of learning, particularly in developing students' cognitive and communication skills in inorganic chemistry courses.

Keywords: cognitive, communication, case-based learning model.

▪ INTRODUCTION

The rapid of global changes in education have necessitated innovation and adjustment in teaching methods to meet the demands of the needs of the 21st century (Arifin & Mu'id, 2024). One critical requirement is the development of the 4Cs-critical thinking, collaboration, creativity, and communication (which are essential competencies for modern students). These competencies are particularly significant in higher education, where students are prepared to become prospective educators. A key challenge for universities is to effectively develop these skills in classrooms, especially in science-based disciplines like chemistry.

Higher education, particularly in the context of educational studies, bears the responsibility of preparing graduates who possess not only theoretical knowledge but also practical skills that align with the demands of the contemporary era. Communication competence, both oral and written, is a requisite competency for students seeking to contribute effectively in the world of work (Hajron, 2024). In the context of chemistry education, the ability to convey chemical ideas and concepts clearly and precisely is of particular importance, given the role of students as future educators (Vera, 2020).

Students encounter difficulties in articulating their opinions or elucidating the concepts they have acquired, both in oral and written formats. The students' limited communication abilities represent a significant rationale for undertaking this research project. Furthermore, conventional learning methodologies frequently fail to allocate sufficient time for students to engage in rigorous communication and interaction. Consequently, this study was designed to assess the extent to which the CBL model, when

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integrated with discussion and question-and-answer techniques, can facilitate the enhancement of students' communication competencies (Safira et al., 2021).

Case-Based Learning (CBL) is a pedagogical approach that employs the analysis and resolution of authentic cases to facilitate the acquisition of knowledge and skills pertinent to the subject matter under study (Arianto & Fauziah, 2020). The objective of this model is to facilitate active student involvement in the learning process through case analysis and problem-solving (Asmiyunda & Hardeli, 2023). The CBL model encourages students to engage in critical thinking, explore a range of potential solutions, and bridge the gap between theoretical knowledge and practical application (Sanova et al., 2023). This is consistent with the requirements of 21st-century learning, which places an emphasis on the development of higher-order thinking skills. The implementation of the CBL model in chemistry education has the potential to enhance the quality of learning, particularly in disciplines that necessitate a comprehensive understanding, such as inorganic chemistry. By utilizing authentic cases as educational resources, students not only commit concepts to memory but also comprehend their practical applications in real-world scenarios (Nisa et al., 2023). This approach also fosters greater student engagement and motivation in the learning process.

The CBL model provides opportunities for students to engage in group collaboration, discourse, and opinion exchange (Liu & Pásztor, 2022). This discussion process is instrumental in enhancing students' communication competencies, encompassing the conveyance of ideas and active listening and responding to others' perspectives. Consequently, the implementation of the CBL model in learning is anticipated to address the limitations of conventional learning, which is comparatively less interactive.

One efficacious method for enhancing students' communication abilities is through the integration of the CBL model with discussion and question-and-answer techniques. This combination provides an opportunity for students to practice critical thinking through case analysis, as well as to enhance their communication skills in the context of class discussions. In the CBL model, students are confronted with authentic cases that they must resolve through group discussions (Arianto & Fauziah, 2020). This discussion process not only facilitates a deeper comprehension of the material but also strengthens their capacity to convey ideas in a clear and structured manner.

The question-and-answer method is a valuable tool for enhancing students' communication abilities. This method encourages students to engage in active questioning and answering during the learning process (Khasanah et al., 2024). Furthermore, instructors can facilitate more profound discourse by posing thought-provoking inquiries, which compels students to engage in more rigorous thinking and effectively convey their responses. The combination of CBL models and discussion and question-and-answer methods provides students with the opportunity to gain a deeper understanding of the subject matter while also developing their communication skills (Nisa et al., 2023). This approach is designed to enhance the overall quality of learning and prepare students to navigate the complexities of the professional world, where effective communication is a crucial skill (Harahap & Yusra, 2022).

This research project was conducted with the objective of investigating the potential of the CBL (constructive learning) model as a pedagogical approach for teaching inorganic chemistry 1 in the Chemistry Education Study Program at Jambi University.

This course was selected for investigation due to the inherent complexity of the subject matter, which necessitates a pedagogical approach that enables students to grasp the fundamental principles of inorganic chemistry and connect them to tangible phenomena. Previous assessments revealed suboptimal learning outcomes, with 64% of students scoring below 73. The CBL model was selected as the learning model due to its capacity to integrate theoretical knowledge with practical applications through case analysis, as well as its effectiveness in enhancing students' critical thinking and communication skills. Furthermore, this study aims to assess the extent to which the integration of the CBL model with discussion and question-and-answer methods can enhance students' cognitive and communication skills in inorganic chemistry courses. The findings of this study are anticipated to inform the development of a more interactive and effective learning model, as well as contribute to the improvement of learning quality in higher education.

▪ METHOD

Participants

The population in this study was two classes taking inorganic chemistry courses in semester 3 (three) at Jambi University. The research sample was taken from 1 (one) class consisting of 30 students. All of these students will complete a pretest and posttest to assess changes in their cognitive and communication skills. The sampling technique used in purposive sampling is to obtain samples that are in accordance with the research objective and meet the desired criteria.

Research Design and Procedures

This study employed an experimental method with a one-group pretest-posttest design, which lacked a control group (Sugiyono, 2017). The design was chosen so that one group would receive intensive and planned treatment so that the result obtained would be more optimal. The objective was to assess the efficacy of the case-based learning (CBL) model when integrated with question-and-answer methods and class discussions, in enhancing students' cognitive and communication abilities. This research was conducted during 1 (one) effective semester. The research design can be delineated as follows: O1 X O2. Description of sign research design of O1 for pretest measurement (before the implementation of the CBL model). Sign X for the treatment or learning process (the implementation of the CBL model integrated with question and answer methods and class discussions). Sign O2 for post-test measurement (after the implementation of the CBL model).

The research procedure will be conducted as follows: the preliminary stage, the implementation stage, and the assessment stage. The preliminary stage includes the creation of learning tools that employ the CBL model and case scenarios pertinent to the inorganic chemistry curriculum. Develop the instruments to be used for the pretest and posttest in order to measure cognitive and communication skills. Develop guidelines for question-and-answer sessions and class discussions that are integrated into CBL learning.The implementation stage includes the prettest that was administered to the students in order to ascertain their initial abilities. The CBL learning model was employed, wherein students were presented with case scenarios pertaining to inorganic chemistry. During this process, question-and-answer methods and class discussions were utilized to enhance comprehension and refine communication skills. Subsequent to the conclusion of the entire learning series, students were administered a post-test to ascertain

the extent of change in their cognitive and communication skills. The assessment stage includes lecturers conducting cognitive assessment and communication assessment of pretest and posttest results. Cognitive assessment is carried out by giving questions, while communication assessment is carried out during the learning process.

Instrument

The data collection instruments employed were cognitive test questions and communication observation questionnaires. The cognitive tests comprise pretest and posttest questions, which are used to assess students' cognitive abilities with regard to the comprehension of inorganic chemistry material. The communication observation questionnaire was utilized to assess communication competencies during classroom discourse. The data collected can be classified as cognitive data, specifically comprising pretest and posttest scores pertaining to cognitive abilities. The communication data is presented in the form of qualitative and quantitative assessments of communication skills, based on observations of student interactions during the class discussion and question-and-answer process.

Data Analysis

The data analysis techniques employed were the normality test and the paired sample test (Sundayana,2016). Additionally, the effect size test was conducted to ascertain the extent of improvement in students' cognitive and communication skills. All research data will be analyzed with the assistance of the SPSS software. The results of the effect size test can be interpreted with an effect size value <0.20 (low), an effect size value of 0.20 - 0.80 (medium), and an effect size value> 0.80 (high) (Demirel & Dağyar, 2016).

▪ RESULT AND DISSCUSSION

The objective of this study is to assess the efficacy of the implementation of case-based learning (CBL) models integrated with question-and-answer methods and class discussions in enhancing students' cognitive and communication abilities. The findings of this study encompass two pivotal phases: pretests and posttests. These were subjected to rigorous statistical analysis to ascertain the existence of notable discrepancies between students' capabilities prior to and following the learning process (Sundayana, 2016).

The implementation of the Case-Based Learning (CBL) model, integrated with question-and-answer methods and class discussions, in teaching chemical bonds is proven effective in facilitating understanding. This approach makes concepts such as ionic and covalent bonds more relatable and applicable, enabling students to connect them with phenomena they encounter in everyday life. At the problem orientation stage, the introduction of basic concepts of chemical bonds and their relationship to real-world contexts provides students with a meaningful foundation to grasp the relevance of the material. Real-life examples, such as the difference in solubility between table salt (NaCl) and oil in water, effectively trigger students' curiosity. This not only enhances their understanding of bonding concepts but also bridges theoretical knowledge with practical experiences (Herman et al., 2022).

The group discussion process, followed by question-and-answer sessions and the presentation of discussion results, offers students the opportunity to collaborate, think critically, and refine their communication skills (Dewi et al., 2024). Probing questions

posed by the lecturer are instrumental in guiding the discussion and deepening students' comprehension, while also encouraging them to share knowledge with their peers. Class discussions that allow students from different groups to pose questions and provide feedback further enrich their understanding. This dynamic and interactive learning environment enables students not only to listen but also to actively participate in the learning process. The lecturer's concluding remarks at the end of each session are crucial for connecting various ideas and reinforcing the concepts learned. Feedback provided by the lecturer at this stage clarifies misunderstandings and deepens students' comprehension of the differences between ionic and covalent bonds and their real-world applications.

The integration of the question-and-answer method within the Case-Based Learning (CBL) model is designed to deepen students' understanding of the given cases and foster critical thinking skills (Arianto & Fauziah, 2020). During the data collection and case analysis stages, students are encouraged to ask and answer questions related to the phenomena being studied, engaging with both the lecturer and their peers. For example, in learning about ionic and covalent bonds, lecturers may initiate discussions with trigger questions such as, "Why does NaCl have a higher melting point than H_2O?" or "What makes water molecules polar?" These questions prompt students to find answers by connecting theoretical concepts with real-life contexts. Additionally, students are encouraged to pose their own questions as part of a deeper exploration of the material, creating a more interactive and two-way discussion environment.

In this process, the lecturer acts as a facilitator, guiding students to develop logical and structured answers. The question-and-answer method also helps to clarify misconceptions or expand discussions based on students' responses. For instance, when a student answers that NaCl dissolves in water due to ionic interactions with water molecules, the lecturer can follow up with deeper questions, such as, "How does the hydration process of Na^+ and Cl^- ions affect the solubility of NaCl?" This approach not only enhances conceptual understanding but also trains students to articulate their ideas clearly and defend their arguments effectively. Thus, the integration of the question-and-answer method within the CBL model enriches learning, strengthens critical thinking skills, and boosts students' confidence in expressing their ideas (Yuni et al., 2024).

Description of Pretest and Posttest Data

The research was conducted on 30 students by analyzing cognitive and communication skills before (pretest) and after (posttest) learning CBL model. The pretest results showed that most students had cognitive abilities that were classified as moderate to low, with an average score of 36.97. While students' communication skills in the pretest also showed unsatisfactory results with an average score of 49.53.

After the application of the CBL learning model, there was a significant increase in the posttest results. Students' cognitive abilities increased to an average of 74.40, while students' communication skills also increased to an average of 69.93. This shows a significant improvement in both aspects after learning with the CBL model, which is integrated with the question-and-answer method and class discussion. With this model, students are encouraged to ask and answer questions actively during the learning process (Khasanah et al., 2024). Description of pretest and posttest results on cognitive abilities and communication skills can be seen in Table 1.

Table 1. Data description of cognitive ability and communication ability

	N	Minimum	Maximum	Mean	Standard Deviation
Cognitive Pretest	30	0	73	36.97	23.949
Cognitive Posttest	30	36	100	74.40	17.286
Communication Pretest	30	33	89	49.53	17.718
Communication Posttest	30	56	100	69.93	15.805

The notable enhancement in the post-test can be attributed to the alteration in class dynamics throughout the learning process. Prior to the implementation of the CBL model, students exhibited a tendency to be passive and inactive in expressing their opinions or answering questions posed by the lecturer. However, following the introduction of the CBL model, students demonstrated a notable increase in courage, becoming more willing to express their opinions, ask questions, and answer questions in a more informed manner. Class discussions became more dynamic, and students exhibited a marked improvement in their ability to convey their ideas in a structured manner, as evidenced by the enhanced communication assessment results observed in the post-test (Tendrita & Sari, 2020).

Results of the Effectiveness Test

The efficacy of the CBL model was evaluated through a series of statistical assessments, including normality tests, paired sample tests, and effect size tests. The normality test was conducted to ascertain whether the pretest and posttest data were normally distributed. A total of 30 samples were utilized for the normality test, and the resulting data were analyzed using the Shapiro-Wilk test. The results of the normality test indicate that the data distribution is not normal, with a significant value (sig) on cognitive pretests, cognitive posttests, communication pretests, and communication posttests, all of which are less than 0.05. The subsequent data normality test results are presented in Table 2.

Table 2. Data normality test

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig	Statistic	df	Sig
Cognitive Pretest	.225	30	<.001	.838	30	<.001
Cognitive Posttest	.274	30	<.001	.793	30	<.001
Communication Pretest	.186	30	.010	.893	30	.006
Communication Posttest	.168	30	.031	.904	30	.011

The results of the normality data test showed that the research data were not normally distributed, so that the paired sample test chosen was the sign non-parametric test. Sign's non-parametric test was conducted to determine the relationship between pretest and posttest samples. The results of the Sign non-parametric test show that there are differences in the results of pretests and posttests on cognitive abilities with an Asymp.Sign value <0.05. As for the results of pretests and posttests on communication skills, they also show the value of Asymp.Sign <0.05. Thus it can be concluded that there is a significant difference between the pretest and posttest results on cognitive ability and communication skills of students after the application of CBL model. The results of the sign nonparametric statistical test can be seen in Table 3.

Table 3. Nonparametric sign test

	Post-test Cognitive-Pretest Cognitive	Post-test Communication-Pretest Communication
Z	-5.295	-5.199
Asymp.Sign (2-tailed)	<.001	<.001

Subsequently, the outcomes of the normality tests and nonparametric paired sample tests were followed by effect size testing, which was employed to assess the efficacy of the CBL model. The results of the effect size test revealed a cognitive ability score of 0.684 (medium category) and acommunication skills score of 0.671 (medium category). These findings indicate that the implementation of the Case-Based Learning (CBL) model, integrated with the question-and-answer method and class discussions, is an effective approach to learning. The results of the effect size tests are presented in Figure 1.

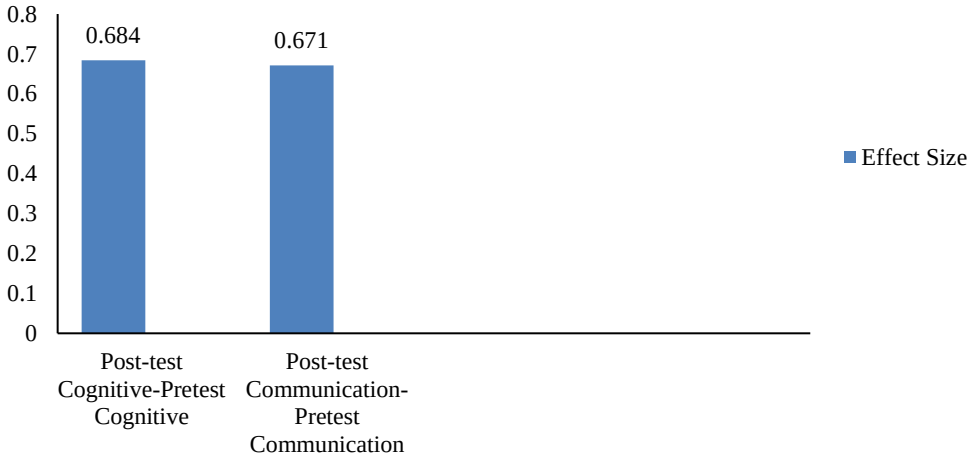

Figure 1. Effect size test

The value falls within the medium to high category, indicating that this approach positively impacts students' understanding of concepts and their ability to convey ideas effectively. Integrating this method enables students to actively engage in the learning process, develop critical thinking skills, and enhance their communication abilities through meaningful interactions during discussions. Therefore, the collaboratively applied CBL model can serve as an effective alternative for improving the quality of learning in higher education.

The results demonstrated that the CBL model, when integrated with question-and-answer and class discussion methods, was an effective approach for enhancing students' cognitive and communication skills (Nisa et al., 2023). Furthermore, this integration resulted in the creation of a more collaborative and interactive learning atmosphere, which is a crucial element in the development of 21st-century skills. This process is anticipated to enhance the quality of learning, equipping students with the necessary skills to navigate the complexities of the modern workplace (Harahap & Yusra, 2022).

In conclusion, the evidence presented in this study indicates that the application of the case-based learning (CBL) model, when integrated with the question-and-answer

method and class discussion, has the potential to enhance students' cognitive and communication skills.

▪ CONCLUSION

The implementation of the Case-Based Learning (CBL) model, integrated with a question-and-answer methodology and class discussion, has demonstrated that this model is an effective approach for enhancing students' cognitive and communication abilities. This approach entails students' active involvement in the analysis of authentic cases pertaining to the learning materials. The implementation of discussion and question-and-answer techniques fosters a culture of intellectual courage, wherein students are emboldened to express their opinions and engage in discourse. This contributes to a more interactive and collaborative classroom atmosphere, which is conducive to the development of critical thinking and communication skills, two abilities that are highly valued in the contemporary educational context. Therefore, the CBL model is effective in creating a more dynamic learning environment, enhancing the quality of education, and preparing students to navigate the challenges of the modern workplace that require good critical thinking and communication skills.

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