

Implementation of Problem-Solving Learning to Improve Critical Thinking Ability of Chemistry Students

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ABSTRACT

English abstract only consisted of one paragraph
This class action research aims to describe how to
implement the Problem Solving (P.S.) model that
can improve chemistry primary students' critical
thinking skills (K.B.K.). The research subjects
included 36 Chemistry Education study program
students taking the Advanced Basic Chemistry
course. The main instrument in this study was
the researcher, who used observation sheets.
There are four phases in this study. Each cycle is
planning, implementation, evaluation, and
reflection. The steps of problem-solving are
determining the problem (by writing down the
known data), Designing a solution strategy (by
writing down the formula or method used,
solving the problem, and reviewing the problem-
solving (by asking if the solution is by the
concept). These steps improve critical thinking
skills, especially in analysing, inferring,
deducing, and evaluating.

INTRODUCTION

Critical thinking is one of the most essential skills for students in this era of globalization. This ability enables students to analyze, evaluate, and synthesize information effectively in a world of fast-changing and complex information. Thus, students can make more rational and logical decisions, which are indispensable in facing challenges in various fields of life (Facione, 2020; Sael et al., 2019). Critical thinking skills are essential in education, especially in chemistry, because they help students understand complex chemical concepts and apply them in various real-life contexts (Raviolo, 2023; Danial & Yunus, 2019). This shows that the mastery of critical thinking skills not only has an impact on academic achievement but also on students' ability to contribute significantly to society.

Along with developing the educational paradigm, a student-centered learning approach is increasingly emphasized. According to Weimer (2013), good learning places students at the center of the learning process. In this context, students are the recipients of information and the main actors in the learning process. One approach widely recognized for effectiveness is Problem-Solving (PS) based learning. This learning model places students at the center of the learning process, where they are required to be active in understanding problems, designing solutions, implementing solutions, and evaluating the results (Jonassen, 2017; Nicholus et al., 2023; Alberida et al., 2019). Thus, problem-solving-based learning facilitates mastery of the material and encourages the development of students' critical thinking skills.

According to research conducted by Kanphukiew and Nuangchalerm (2024), applying the PS model can significantly improve students' critical thinking skills, especially in science learning. This research shows that when students face real situations requiring problem-solving, they tend to be more engaged and motivated to learn. This creates a dynamic learning atmosphere where students can discuss with each other, share ideas, and collaborate in finding solutions. Therefore, applying problem-solving-based learning models is a strategic step in improving the quality of education, especially in fields that require deep understanding, such as chemistry.

However, the challenge many lecturers face in implementing PS learning is the tendency to continue using traditional learning methods, such as verification, especially when dealing with complex material such as Acid-Base Equilibrium. Although this method is considered more efficient in terms of time, it could be more effective in improving students' critical thinking skills (Bawden, 2015; Rosa & Azizah, 2020). In many cases, traditional methods tend to emphasize the mastery of facts and information without providing space for students to explore and reflect on their thought processes. Therefore, efforts are needed to integrate the PS model into chemistry learning to achieve more holistic learning goals.

This study aims to describe how the problem-solving (PS) model can be implemented to improve the critical thinking skills (KBK) of students majoring in chemistry. By adopting this model, students are expected to be able to solve chemical problems better and develop critical thinking skills that will be useful

for them in the future. This research focuses on developing teaching methods that are innovative and relevant to the needs of students, as well as exploring how the application of the PS model can have a positive impact on the teaching and learning process. Through this research, it is expected to find effective strategies that lecturers in teaching chemistry courses can adopt.

The novelty of this research lies in the approach used in applying the Problem-Solving model in the context of chemistry education. Although many previous studies have discussed the importance of critical thinking, this research seeks to fill the gap by providing concrete examples of how the PS model can be effectively implemented in chemistry learning. In addition, this research will also explore the impact of implementing this model on improving students' critical thinking skills, as well as how students respond to this innovative learning method. Thus, this research provides not only theoretical but also practical contributions to the world of education, significantly improving the quality of learning in the field of science.

The urgency of this research is very high, given the challenges students face in the increasingly competitive era of globalization. In a changing world, thinking critically is one of the skills needed to face complex problems and challenges. Therefore, this research focuses on developing learning methods that can improve students' critical thinking skills to be better prepared to face challenges in the world of work and everyday life. In addition, with the increasing need for quality education, this research is expected to provide insights and recommendations for educational institutions in designing a more relevant and practical curriculum to prepare students for a better future.

Thus, this research not only contributes to the development of science but also provides direct benefits for students and lecturers in improving the quality of education in chemistry. In a broader context, the results of this research are expected to be a reference for the development of other learning models that can be applied in various disciplines to create a generation that is more critical, creative, and ready to face global challenges

LITERATURE REVIEW

Critical thinking is a potential that everyone has, and this ability can be measured, trained, and developed (Lambertus, 2009). In this case, critical thinking is not just an intellectual ability but also a skill that allows a person to become skilled and active in understanding, applying, synthesizing, and evaluating various information obtained from observation, reflection, reasoning, communication, and experience (Liberna, 2012, Spector & Ma, 2019, Rahman, 2019). In other words, critical thinking is a process that involves various interconnected cognitive and affective aspects. Therefore, educational institutions need to create a learning environment that supports the development of these skills so that students can practice and hone their critical thinking skills optimally.

Problem learning not only helps students solve problems but also develops critical thinking skills, which are part of 21st-century skills, namely Critical thinking, Creativity, Collaboration, and Communication (Trilling & Fadel, 2009). The steps in the PS model, as proposed by Folya (1999), include

understanding the problem, designing the solution, implementing the solution, and improving the problem-solving. These steps emphasize not only the problem-solving itself but also the underlying critical thinking process (Alberida & Barlian, 2019). Thus, students learn to find answers and understand the process needed to reach those answers. This is particularly important in chemistry education, where students are often exposed to abstract and complex concepts.

PS is a constructivist-based learning strategy involving real-life problems as the learning driver. Modifying problem-solving strategies has been shown to improve learners' problem-solving ability (Jusniar et al., 2023). In this context, students are invited to see the relevance of the material they learn to everyday life to appreciate better and understand the importance of chemistry. With this approach, students are taught to memorize formulas or concepts and invited to think critically about how chemistry can be applied in real situations (Costa et al., 2023). This can increase students' interest and motivation to learn and prepare them for the challenges in the increasingly complex world of work.

METHODOLOGY

This research is a classroom action research that aims to improve the learning process of students in the Advanced Basic Chemistry course at the Chemistry Education Study Programme FMIPA UNM. In this study, the researcher acts as the main instrument. The subjects in this study were students of the Chemistry Department of the Chemical Education Study Program class 2023 Class A, as many as 36 participants, and the research location at the UNM Parangtambung FMIPA Campus of the Chemical Education Study Program.

Data sources in the study were obtained from FGDs, interviews, documentation, questionnaires, observation sheets, and KBK-based learning outcomes tests. FGDs were conducted with advanced Basic Chemistry lecturers, the research team, and several other chemistry lecturers.

This research was conducted in 2 cycles. The research design used refers to the Kemmis and Taggart model in Arikunto (2009: 16) which consists of 4 stages in each cycle, namely: planning, action, observation, and reflection. The research design cycle chart is shown in Figure 1 below.

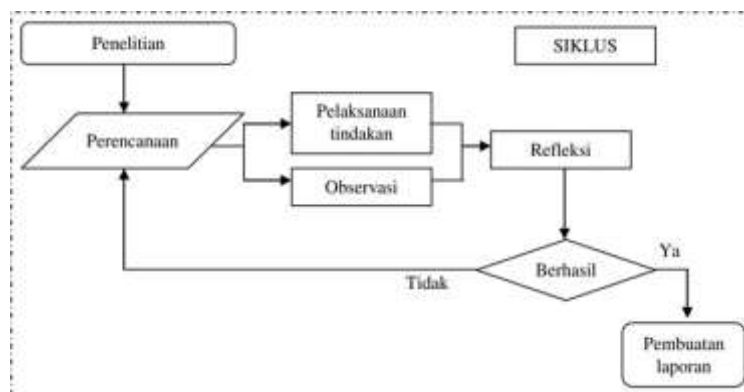


Figure 1: Cycle Model of Classroom Action Research (PTK) according to Kemmis & Taggart

Planning Stage

The planning stage begins with determining the subject, time, and place of the research. The subjects in this study were 36 students of the Department of Chemistry, Chemistry Education study program class 2023. The research location was at the UNM Parang Tambung FMIPA Campus, and the research was conducted during the advanced basic chemistry course schedule. The selection of participants was based on the heterogeneous abilities of students and the results of problem identification conducted by researchers during preliminary research. This research was conducted in the semester of 2023/2024.

Furthermore, initial observations and interviews with five students were conducted to identify problems. Observations and interviews were conducted to get an initial picture of Advanced Basic Chemistry learning and students' critical thinking skills, especially in the semester 2023/2024.

Researchers then designed everything needed in the learning process at the action implementation stage, namely learning tools and research instruments, which were then validated by a team of validators. The researcher also asked for help from 2 peers as observers in implementing the research. The learning tools used in this study are teaching materials, MFIs, and assessments.

Action Implementation Stage

In the action implementation stage, lecturers as researchers carry out learning activities by the RPS and SAP that have been validated. Learning is carried out in three meetings, which are incorporated in 1 cycle. The primary step of learning activities is learning with a problem-based learning model.

Observation Stage

Observation is the stage of collecting data for evaluation and reflection. During the implementation of learning, observations were made of student activities in conducting learning with the PS model. The observation was conducted by two peer lecturers. The observation sheet format was designed by the researcher, and the filling was done by marking (√) in the specified column. To complement the data, observation also used photos.

Reflection Stage

Reflection evaluates the actions taken in the learning process to be improved in the next cycle. It is carried out based on the results of observations and then implemented in cycle 2.

RESEARCH RESULT

Figure 2 shows the results of observations of student activity in

implementing the learning syntax of the PS model in cycles 1 and 2.

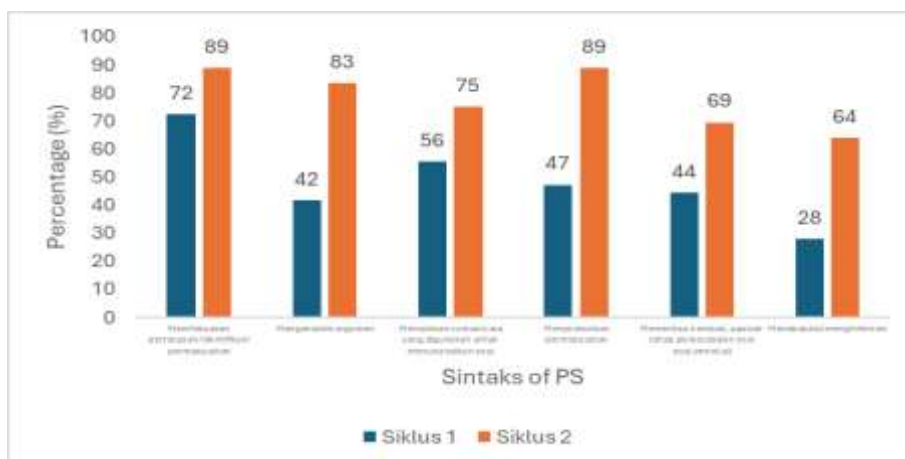


Figure 2. Bar Diagram of Student Activity Observation Results on the Implementation of PS Model Learning Steps cycles 1 and 2

Based on Figure 2, the number of students who were actively involved in each syntax of the PS model increased in cycle 2.

Effective learning in chemistry focuses not only on concept mastery but also on developing students' critical thinking skills. One method that has proven effective is the PS learning model. In this study, the syntax of the PS model was observed in cycles 1 and 2 to improve students' critical thinking skills. The ability to think critically can be seen based on the learning outcomes test that uses KBK indicators. The results of the KBK test in cycles I and II can be seen in Figure 3.



Figure 3. Bar Diagram of KBK Results in cycles 1 and 2

DISCUSSION

In general, this was influenced by strategies that had been improved through the reflection process and greater student involvement in cycle 2. The number of students actively involved in focusing questions or identifying problems in cycle 1 was 72% and increased to 89% in cycle 2. Reflection was carried out by asking all students to identify issues that were previously only represented by group representatives. This shows that by actively involving students in the problem-identification process, they are better able to understand the context of the problem at hand. Research by Hmelo-Silver (2004) also showed that the active involvement of students in learning can improve their understanding of the material.

Student activity in analyzing arguments and solving problems was relatively low in cycle one at 42% and 47%. The activity increased in cycle 2 to 83% and 89% in cycle 2. Reflection was carried out in the form of giving clear directions to each group to write the known data correctly. In the cycle, students were only given directions to write down their understanding in general. This shows that the support given to students in analyzing arguments and solving problems contributed significantly to improving their abilities. Students' understanding of arguments and problem-solving can be enhanced by providing precise and directed instructions. According to research by Zohar and Dori (2003), analyzing arguments is an essential component of critical thinking, which can be developed through problem-based learning.

In cycle 1, student activity in writing the formula or method used to solve the problem was 56% and increased to 75% in cycle 2. The guidance given in cycle one was limited to the direction to write the formula used in solving the problem, so the reflection was carried out in cycle two by providing practical guidance until students could write the right formula. This shows that practical guidance can help students formulate problem-solving steps systematically. In this context, research by Jonassen (2000) emphasizes the importance of learning strategies that support students in organizing their knowledge.



Figure 4. Student activity in Problem-Solving Learning

Students' activity to deduce or infer increased from 28% in cycle 1 to 64% in cycle 2. The reflection, which instructed each student in the group to write conclusions and discuss the general results, proved effective in improving their

inference skills. Research by Facione (2015) shows that the ability to draw conclusions and infer is an essential indicator of critical thinking that can be developed through structured learning.

Thus, the observation results from both cycles show that implementing the PS model can significantly improve the critical thinking skills of chemistry students. Through proper reflection and direction, students become more skilled in identifying problems, analyzing arguments, formulating formulas, solving problems, and drawing conclusions. This is in line with the achievement of critical thinking skills.

Table 1. Reflection Activities of PS Syntax in Cycle 2

No	P.S. Model Steps	Reflection carried out in cycle 1
1	Focusing on questions/identifying problems	I asked each student to identify the problem
2	Analysing arguments	Directing each group to write the known data correctly
3	Note the formula/ method used to solve the problem	Guiding students to write the method or formula used appropriately
4	Solve the problem	Direct students to solve the problem
5	Rechecking whether the problem-solving stage (assessing)	Reviewing the problem-solving by asking whether the solution is by the concept.
6	Deduce/infer	Instructing each student to write conclusions and discuss general results

Critical thinking skills are one of the most important competencies for students, especially in science fields such as chemistry. Critical thinking enables students to analyze information, evaluate arguments, and formulate logical inferences in an educational context. Research shows that critical thinking skills can be measured through various indicators, such as interpretation, analysis, inference, deduction, and evaluation (Facione, 2015). Through the implementation of PS learning, students are expected to improve their critical thinking skills significantly. This problem-based learning challenges students to think critically and invites them to be actively involved in the learning process, thus creating a more dynamic and interactive learning atmosphere.

The critical thinking skills test results in cycles I and II showed a significant increase in several indicators. Analysis indicators show that the average score of 49 in cycle I became 67 in cycle II. This increase was stimulated in the PS syntax, especially in analyzing arguments and writing formulas. Reflection carried out by providing appropriate direction in cycle two can guide students to conduct analyses related to the subject matter and write formulas appropriately. According to Ennis (2016), good analytical skills are needed to solve complex problems in chemistry, where students must understand the interaction between various variables.

Furthermore, the inference indicator also showed a positive increase, from an average score of 55 in cycle I to 69 in cycle II. This indicates that students can increasingly draw logical conclusions from the data provided. The increase was further stimulated in the inference activity in the PS syntax, which gave instructions on how to draw the findings and discuss further to conclude in general. This improvement aligns with the theory that problem-based learning can help students develop their inference skills (Jonassen, 2017). Thus, they learn to remember information and process and analyze it critically so that they can make the right decisions in complex situations.

In the evaluation indicator, there was an increase from the average score of 32 in cycle I to 50 in cycle II. This increase shows that students can increasingly evaluate the arguments and solutions provided in learning. The increase was stimulated in the re-examination activity in the PS syntax by reviewing the problem-solving that has been done. This is important, given that good evaluation allows students to make more informed decisions in a scientific context. The ability to critically evaluate information is necessary, especially in an era where information is easily accessible but not consistently accurate (Machete & Turpin, 2020). By mastering good evaluation skills, students can become more skeptical and analytical, able to distinguish between valid and invalid information.

The interpretation indicator showed relatively stable results, with an average score of 76 in both cycles. This indicates that students already have a strong foundation in interpretation skills but still need to be encouraged to deepen their understanding of the context and meaning of the information provided. According to Halpern (2014), interpretation skills are the foundation of critical thinking and must be maintained so that students can continue developing in other indicators. In this case, teachers need to provide constructive feedback and encourage students to ask questions and discuss so that they can broaden their horizons and improve their understanding of the material learned.

Overall, the results of the KBK test show that the implementation of PS learning has succeeded in improving the critical thinking skills of chemistry students, especially on the indicators of analysis, inference, deduction, and evaluation. Although the interpretation indicator is relatively stable, this provides an opportunity for further development in learning. By continuing to apply interactive and problem-based learning methods, students' critical thinking skills are expected to continue to improve in the future.

Thus, PS has significant implications for improving individuals' critical thinking skills. By engaging in the problem-solving process, individuals are invited to analyze information in depth, evaluate various perspectives, and make decisions based on the available evidence (Facione, 2011). This process encourages individuals not only passively to receive information but also to question and understand the context behind the problem. In addition, by critically analyzing possible alternative solutions, individuals learn to consider the consequences of each choice made (Jonassen, 2020). Consistent application of problem-solving also trains individuals to develop reflective skills, where

they can evaluate the outcomes of decisions made and refine future approaches (Moon, 2008). Thus, active engagement in problem-solving not only enhances technical problem-solving skills but also enriches overall critical thinking ability, which is crucial in everyday life and educational contexts.

CONCLUSIONS AND RECOMMENDATIONS

Based on the research that has been done, it can be concluded that the implementation of the P.S. model that can improve the K.B.K. of students majoring in chemistry includes six stages, namely:

1. Focusing questions/identifying the problem
2. Analysing arguments
3. Note the formula/ method used to solve the problem
4. Solve the problem
5. Rechecking whether the problem-solving stage (assessing)
6. Deduce/infer.

ADVANCED RESEARCH

In academia, research often has limitations that need to be acknowledged in order to provide a clearer picture of the validity and generality of the findings. This study focused on chemistry students, so there are some limitations that need to be considered, especially in terms of the generality of the findings. Although the results of this study indicate an increase in students' critical thinking skills, it is important to note that the characteristics of the material and learning approaches in chemistry can differ significantly from other fields of study. For example, in engineering or social science education studies, the learning methods and contexts used may be very different, which may affect the results of the implementation of problem-based learning (PS). Therefore, although these findings provide valuable insights, they cannot be directly generalized to other disciplines without further research that considers the specific context of each field.

Furthermore, the influence of external factors also needs to be considered. The observed increase in critical thinking skills cannot always be directly attributed to the implementation of PS. There are many other factors that can influence the results, such as student learning motivation, lecturer involvement in the learning process, the availability of adequate learning facilities, and the support of the academic environment as a whole. For example, students who have high intrinsic motivation tend to be more active in the learning process and are better able to develop their critical thinking skills. Therefore, to gain a more comprehensive understanding of the effectiveness of PS, further research needs to consider various external factors that may contribute to the results obtained.

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