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Development of a Problem-Based Learning Model to Enhance Students' Metacognitive Skills

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Abstract: Students' metacognitive skills refer to strategies for how one learns (how to learn) and how one thinks (thinking about thinking); metacognition plays a role in communication, self-control, memory, problem-solving, and personality development. This study aims to determine: (a) how the implementation of learning using learning tools oriented toward the problem-based learning model proceeds; (b) how students engage in activities when applying learning tools oriented toward the problem-based learning model; and (c) whether there is a difference in students' metacognitive abilities after being taught using the problem-based learning model. The research sample consisted of 56 students at HKBP Nommensen University in Pematangsiantar. The research method employed was research and development (R&D) based on the procedural model developed by Borg and Gall. Data collection techniques included a Likert-scale questionnaire, unstructured interviews, and a metacognitive skills test. The results of the study showed that the frequency distribution of students' metacognitive skills indicated that the mean, median, and standard deviation (SD) for metacognitive skills were 55.34, 55.00, and 5.17, respectively. Based on the results obtained in Trial II, students' metacognitive skills fell into the good and moderate categories, whereas in Trial I, students were categorized as moderate and below average. Students categorized as good accounted for 21.92%, and those categorized as moderate accounted for 78.07%. Meanwhile, in Trial I, 21.34% of students were categorized as average and 78.66% as below average. It was concluded that the PBL model is suitable for improving students' metacognitive skills.

Keywords: Problem-Based Learning, Metacognition.

INTRODUCTION

The development of information and communication technology across various aspects of life today plays a strategic role in the 21st century (Asister *et al*., 2022). Technological advancements have led to changes in the qualifications and competencies required of the workforce to fill specific positions (Cengelci & Egmir, 2022). Changes in academic performance standards have occurred alongside the development of Information and Communication Technology (ICT) and global economic growth (Panigrahi & Verma, 2025). Jobs requiring expert-level thinking and complex metacognitive skills have been steadily increasing since the 1960s, while jobs involving manual skills began to decline in the early 1970s (Popandopulo *et al*., 2025). This is supported by a survey conducted by the Boston Advanced Technological Educational Connection (BATEC) on the skill requirements of workers (Fauzi & Sa'diyah, 2019). Based on this research, it was concluded that the competencies required of workers today include metacognitive skills, the ability to work productively in teams and groups, self-evaluation and time management, as well as problem-solving skills.

The 21st-century competency framework serves as the foundation for the development of the Indonesian National Qualifications Framework (KKNI), which is designed to anticipate 21st-century competency needs. The KKNI was developed to address future demands that are intensifying competition in life and directly impacting the need for improved human resources. Ministry of Education and Culture Regulation No. 61 of 2014 on the Implementation of the KKNI explains that to meet future competency needs, the skills required of students include: metacognitive skills, problem-solving skills, communication skills, critical and creative thinking to thrive in a global society, a broad interest in life, readiness for work, intelligence aligned with their talents and interests, and a commitment to the environment. Considering the demands for a shift in the 21st-century mindset mentioned above, one of the competencies that must be developed is metacognitive skills.

In the field of education, metacognition is often associated with efforts to optimize an individual's problem-solving abilities (Talwal *et al*., 2022). In line with this, Winkel argues that cognitive strategies are the ways in which an individual manages their own cognitive activities, particularly in learning and thinking (Kusuma & Iva, 2023). One type of higher-order thinking skill is metacognition (Fleur *et al*., 2021). Metacognition is thinking about how one thinks; it is a learner's conscious ability to monitor the learning process (Krieger *et al*., 2022). Several sources discuss

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metacognition, including: it is a strategy for how one learns (how to learn) and how one thinks (thinking about thinking); metacognition plays a role in communication, self-regulation, memory, problem-solving, and personality development. In line with this definition, Paidi states that metacognition is also related to the regulation of cognitive components that enable students to understand the tasks or problems they face so that these problems can be successfully resolved (Ulya *et al*., 2024). Developing metacognitive skills in students is a valuable educational goal, as these skills can help them become self-regulated learners, as noted by Eggen and Kauchak (2012). Metacognitive skills are also defined as metacognitive awareness (Santengelo *et al*., 2021). This term refers to an individual's perception of their knowledge regarding the state and processes of their own thinking, as well as their ability to initiate and adjust these processes according to the situation (Stanton *et al*., 2021). To clarify the focus of this study, the metacognitive ability in question refers to students' self-evaluation of the metacognitive skills they possess individually. Meanwhile, the term "skill," as defined by the KBBI (Kamus Besar Bahasa Indonesia), refers to a person's ability or proficiency in using language correctly and appropriately. Based on this definition, the researcher can specifically define metacognitive skills as a person's thinking abilities, encompassing prediction skills, planning skills, monitoring skills, and evaluation skills.

Based on the results of the questionnaire and student observations, it was concluded that metacognitive skills remain low. This is evident in the fact that students often feel nervous and lack confidence when giving presentations in front of the class. Additionally, students in the audience stated that they did not fully understand what their peers were presenting. Those students who did not understand simply remained silent and did not dare to ask questions; as a result, they were unable to grasp the concepts presented during the activity. Based on the observation results, it was also found that only a few students actively asked questions or dared to express their opinions during the learning activities. The rest of the students were merely passive and even created their own disturbances. Furthermore, when the instructor asked questions, the students remained silent and did not provide answers. Another observable indication is that students tend to be afraid to offer ideas or comments and lack confidence in communicating, reflecting their still-low level of metacognitive skills.

The KKNI content standards include a policy stating that learning should focus on developing metacognitive skills; however, this is still limited to learning activities aimed at lower-level learning outcomes (LOTS). The core competencies in each learning activity—which largely link the material to everyday life—should be utilized to connect the concepts in the material with metacognitive skills.

With reference to the learning model to be developed—namely, problem-based learning—to enhance metacognitive skills. Based on the above discussion, there is a need to develop learning approaches that can enhance metacognitive skills.

RESEARCH METHODOLOGY

This study employed a pre-experimental design with a one-group pretest-posttest design, utilizing the Problem-Based Learning (PBL) model to enhance students' metacognitive skills in science education. The research approach utilized a mixed-methods design, combining qualitative and quantitative research methods. This study is a research and development (R&D) project in the field of education, employing Thiagarajan's 4D model. The research stages consist of three phases: the preliminary phase, the prototype phase, and the assessment phase. This study uses educational design research, which is a research design to develop research-based solutions to solve complex problems in the field of education (Plomp & Nieveen, 2013). The research sample consisted of 56 science education students at HKBP Nommensen University in Pematangsiantar.

Research Findings

The frequency distribution of students' metacognitive skills shows that the mean, median, and standard deviation (SD) for metacognitive skills are 55.34, 55.00, and 5.17, respectively. The results of the normality test for the metacognitive skills variable yielded: calculated $\chi^2 = 3.50$ and table $\chi^2 = 12.59$ (calculated $\chi^2 <$ table χ^2), so it can be concluded that the sample comes from a normally distributed population. The distribution of students' metacognitive skills scores is presented in Figure 1.

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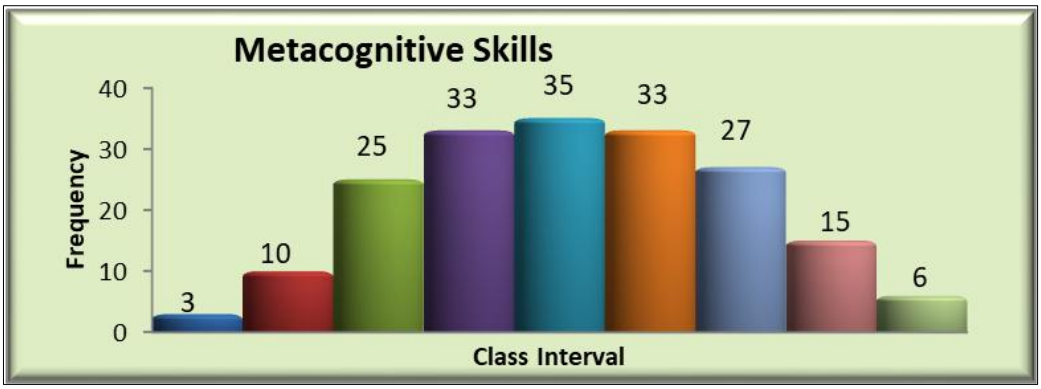

Figure 1. Histogram of Students' Metacognitive Skills Scores

Based on the results of the data analysis and with reference to the value conversion (Gronlund, 1982), the students' metacognitive skills were categorized and are presented in Table 1.

Table 1. Students' Metacognitive Skill Levels (Pilot Study I)

Number	Interval	Frequency	Frequency (%)	Kategory
1.	80 – 100	-	-	Very Good
2.	60 – 79	-	-	Good
3.	40 – 59	38	21.34	Medium
4.	20 – 39	140	78.66	Low
5.	< 20	-	-	Very Low

The results of the second experiment for the variable of students' metacognitive skills are presented in Table 2.

Table 2. Students' Metacognitive Skill Levels (Trial II)

Number	Interval	Frequency	Frequency (%)	Kategory
1.	80 – 100	-	-	Very Good
2.	60 – 79	41	21.92	Good
3.	40 – 59	146	78.07	Medium
4.	20 – 39	-	-	Low
5.	< 20	-	-	Very Low

Based on the results obtained in Trial II, students' metacognitive skills fell into the "good" and "moderate" categories, whereas in Trial I, students were categorized as "moderate" and "poor." Students categorized as "good" accounted for 21.92%, and those categorized as "moderate" accounted for 78.07%. Meanwhile, in Trial I, students categorized as "moderate" accounted for 21.34%, and those categorized as "poor" accounted for 78.66%.

CONCLUSION

1. The results of the study show that the frequency distribution of students' metacognitive skills indicates that the mean, median, and standard deviation (SD) for metacognitive skills are 55.34, 55.00, and 5.17, respectively. From the results of the normality test for the metacognitive skills variable, we obtained: calculated $\chi^2 = 3.50$ and table $\chi^2 = 12.59$ (calculated χ^2 < table χ^2), so it can be concluded that the sample comes from a normally distributed population.
2. Based on the results obtained in Trial II, students' metacognitive skills fell into the "good" and "moderate" categories, whereas in Trial I, students were categorized as "moderate" and "poor." Students categorized as "good" accounted for 21.92%, and those categorized as "moderate" accounted for 78.07%. Meanwhile, in Trial I, 21.34% of students were categorized as average and 78.66% as below average. It was concluded that the PBL model is suitable for improving students' metacognitive skills.

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