

Critical Thinking in Infrastructure Management: A Problem Based Learning Approach

Heri Pratikto, Madziatul Churiyah*, Elvira Nur Azizah
Department of Management, Faculty of Economics and Business, Universitas
Negeri Malang, Indonesia
Corresponding email: madziatul.churiyah.fe@um.ac.id

Abstract: The growth of industrial revolution 5.0 technology provides opportunities for innovation in technology-based learning models to improve critical thinking skills. The purpose of this research is to improve critical thinking skills and student learning outcomes at Al-Islahiyah integrated vocational school through the application of the problem-based learning model with the help of Genially media. This research involved classroom action research, which was carried out for two cycles, the research subjects were class of office management automation students. The data were obtained through observation, interviews, tests, documentation, and field notes. Data analysis consists of data reduction, data presentation, and drawing conclusions. The results of this research showed that the application of the problem-based learning model with the help of the media can significantly improve student's critical thinking skills and learning outcomes, as well as learning activities according to the steps of problem-based Learning.

Keywords: Problem-based learning, Genially, Critical thinking, Learning outcomes

INTRODUCTION

Industrial Revolution 5.0 embodies the integration of humans and technology, requiring individuals, including students, to possess competencies aligned with industry demands. Among these competencies, critical thinking ability holds significant importance (Kahar et al., 2021; Nirahua et al., 2020). Critical thinking ability entails a cognitive process involving the evaluation, selection, and resolution of problems, decision-making, and the assessment of facts, assumptions, and logical reasoning through rational justifications (Men et al., 2020; Winoto & Prasetyo, 2020a). Critical thinking is a factor that influences learning outcomes (Hadi Santosa et al., 2018a), which refer to behavioral changes observed after completing the learning process (Handayani & Subakti, 2020a). To enhance students' enthusiasm and augment their critical thinking abilities and learning outcomes, technology-based interactive learning media, coupled with an appropriate instructional model, prove effective (Prasistayanti et al., 2019; Tanjung et al., 2023). The problem-based learning (PBL) model, recommended for maximizing learning within the 2013 curriculum, offers a promising approach (Handayani & Koeswanti, 2021a).

PBL is an instructional model centered around problem-solving, aiming to stimulate higher-order thinking skills, problem-solving abilities, and self-regulation among learners (Kartika et al., 2020; Nurrohma & Adistana, 2021). Its core objective lies in cultivating systematic problem-solving skills, thereby fostering criticality in learners' approach to problem resolution (Sharma et al., 2023; Umamah et al., 2018). To engage in critical thinking, learners need to develop diverse strategies to arrive at intelligent conclusions (Wulansari et al., 2019; Zhang et al., 2023). The PBL

model, emphasizing critical thinking skills, offers advantages such as heightened learning enthusiasm, student engagement, and cost-effectiveness of learning activities (Ahmatika, 2017; Liu & Pásztor, 2022). Implementing PBL is expected to enhance students' critical thinking skills and improve their learning outcomes (Aufa et al., 2021; Widayanti, 2020). Considering the benefits of critical thinking skills elucidated, employing PBL can facilitate students' comprehension, particularly in the subject of automation of facilities and infrastructure management.

The critical thinking ability of students in Indonesia is observed to be subpar and requires improvement (Khasani et al., 2019). Similarly, at Al-Islahiyah integrated vocational school, interviews with teachers revealed that students' thinking skills still need enhancement. Students' lack of focus in comprehending the material negatively affects their ability to draw conclusions at the end of learning activities. Furthermore, 36.6 percent of 30 students have not met the minimum completion criteria. At the SMK level, students are obligated to study Automation of Facilities and Infrastructure Management (OTKSP). OTKSP entails studying everything related to facilities and infrastructure. Despite being perceived as an easy subject, OTKSP requires a high level of critical thinking skills as it involves both theoretical knowledge and practical application. The students' low critical thinking skills can be attributed, in part, to the adoption of inappropriate learning models for the material. Previous studies have demonstrated that the PBL model significantly enhances critical thinking skills (Aminullah, 2018; Thorndahl & Stentoft, 2020; Waite et al., 2020)

In this research, the PBL model will be implemented using genially media as a learning model. The objective is to stimulate students' critical thinking skills and improve their understanding of problem-solving concepts and principles during learning activities (Walfajri & Harjono, 2019). The use of electronic media like genially is particularly suitable for the digital era of the 21st century (Putri et al., 2022). Genially is anticipated to foster creativity, enabling students to explore their inherent abilities (Wulansari et al., 2019). With its comprehensive and interactive features, including diverse templates, the creation of learning games, integration of online media, and diverse learning materials, genially is expected to alleviate boredom during the learning process. Therefore, further research employing the Classroom Action Research method is warranted.

This research is significant due to previous findings indicating that the PBL model enhances students' critical thinking skills and learning outcomes (Al-Fikry et al., 2018; Shofwani & Rochmah, 2021). Although the implementation of PBL with genially media has been examined in previous studies, the focus was solely on learning outcomes (Abdurrokhman et al., 2023; Virginia et al., 2021). In contrast, this study considers critical thinking and learning outcomes as variables of interest. The aim is to implement the PBL model with genially media, assess its impact on the activities of both teachers and students, and determine its effects on the critical thinking abilities and learning outcomes.

The remained structure of this paper is provided as follows. The next section is methodology followed by results and discussion. The last section provides the conclusion, limitation, and suggestion for future studies.

METHOD

This study employed a Classroom Action Research methodology, consisting of two cycles. Each cycle encompassed four stages: planning, action implementation, observation, and reflection. The teacher, acting as a researcher, made observations to monitor changes in students' behavior, with the assistance of observers. The observation results were used to inform the planning of actions in the subsequent cycle. This iterative process was repeated until there was a noticeable improvement and the minimum completeness criteria were met. The research was conducted during the even semester of 2022/2023 at SMK Terpadu Al-Ishlahiyah Singosari. The participants of the study were 27 students enrolled in the Office Management Automation (OTKP) 2 class in the twelfth grade.

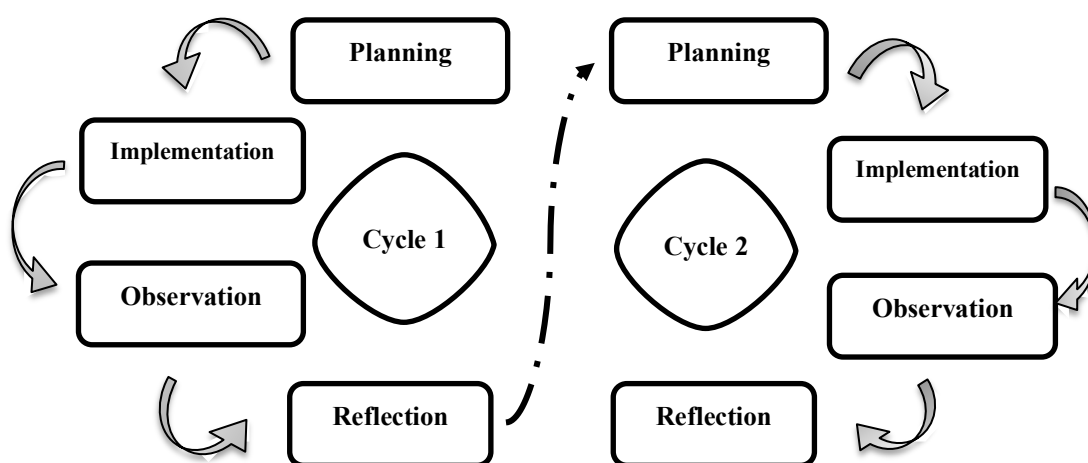


Figure 1. Classroom Action Research Cycle
Source: Nurjannah and Khatimah (2022)

The data that were gathered for this study comprised several components. Firstly, information regarding the learning activities of both students and teachers was collected. Secondly, data on critical thinking skills were obtained, including indicators such as focus, reason, inference, situation analysis, clarification, and overall comprehension. Additionally, data on cognitive learning outcomes were collected, utilizing the same indicators as those used for critical thinking. Lastly, data on psychomotor learning outcomes were gathered, utilizing indicators related to work preparation, work execution, and work results. To analyze the learning activities of students and teachers, a formula was employed and adjusted based on the following criteria:

$$\% \text{ Accomplishment} = \frac{\sum \text{Obtained score}}{\sum \text{Maximum score}} \times 100\%$$

To analyze the success rate of critical thinking skills, the following formula was used:

$$\text{Critical Thinking Ability} = \frac{\sum \text{Obtaines score}}{\sum \text{Maximum score}} \times 100$$

To analyze the success rate of learning outcomes, the following formula was used:

$$\text{Score} = \frac{\sum \text{Obtained score}}{\sum \text{Maximum score}} \times 100$$

Table 1. Criteria for Learning Activities of Learners and Teachers

Score (%)	Criteria
91-100	Very good
81-90	Good
71-80	Moderate
61-70	Less
<60	Fail

Source: Alexander and Pono (2019)

RESULTS AND DISCUSSION

The primary objective of this study was to explore the utilization of genially media in conjunction with Problem-Based Learning (PBL) to enhance students' critical thinking abilities and overall learning outcomes. The research encompassed two distinct cycles: cycle I, which took place from February 13-18, 2023, and cycle II, which was conducted from February 20-25, 2023. The learning activities within each cycle comprised three phases: the initial phase, the core phase, and the closing phase.

Cycle I—Accomplishment of Teacher and Students Activity

Learning activity data was collected through observations conducted by four observers, as well as through field notes that documented the changes in the activities of both students and teachers during the utilization of the Problem-Based Learning (PBL) model with the assistance of genially media. Based on the observations conducted in cycle I, the effectiveness of teacher actions in facilitating learning activities received a score of 83.3%. The teacher's performance in cycle I was deemed satisfactory, demonstrating competent execution of PBL methodology, albeit with certain indicators that remained unfulfilled. Specifically, the teacher exhibited deficiencies in the early learning activities aspect, notably in providing stimulus by reviewing the previous material. Additionally, the researchers observed the changes in student learning activities during cycle I. Student engagement was classified as satisfactory, indicating their ability to effectively participate in PBL learning. However, it was noted that some students did not fully meet the required indicators. The aspects in which students showed lower performance levels included the preparation of genially media, task definition, and problem investigation.

Critical Thinking Ability

Indicators of critical thinking ability were assessed in this study, including the ability to focus on understanding the problem, provide simple reasons, draw conclusions, use appropriate information, provide further explanation, and provide an overall picture. Data on critical thinking ability was collected by evaluating cognitive aspects following problem-based learning (PBL) activities, specifically focusing on

the achievement of the aforementioned indicators. Regarding the focus indicator, students demonstrated the ability to concentrate on describing the meaning of the filling system based on the number system (question number 1) and explaining the purpose of creating inventory documents (question number 3). As for the reason indicator, students were able to provide simple reasons by listing the available office stationery stocks in the company (question number 5), entering the stock information into the stock card (question number 6), and outlining the steps involved in creating Kaulbach storage (question number 7).

Analysis of the inference indicator revealed that students could draw conclusions regarding the utilization of the Kaulbach storage system (question number 8). Moreover, the situation indicator demonstrated that students effectively utilized relevant information by outlining the steps for creating archives using a filling system based on the number system (question number 2) and examining the challenges associated with implementing the archive storage system based on the value of goods (question number 10). Furthermore, the clarify indicator indicated that students were capable of providing additional explanations regarding the steps involved in filing based on the value of goods (question number 9). Lastly, the overview indicator highlighted the students' ability to provide a comprehensive overview by accurately compiling a list of inventory items at school in the correct format (question number 4). The critical thinking ability of learners in the first cycle of the study is presented in Table 2.

Table 2. Critical Thinking Results in Cycle I

Indicator	Item	Score	Remark
Focus	1,3	75	Moderate
Reason	5,6,7	72	Moderate
Inference	8	64	Poor
Situation	2,10	67	Poor
Clarify	9	73	Moderate
Overview	4	76	Moderate
Average		71.03	Moderate

Table 2 reveals the scores obtained for each indicator in cycle I. The indicator with the highest score was "overview," achieving a score of 76, whereas the "inference" indicator had the lowest score of 64. These findings suggest that students demonstrated a commendable ability to review and assess the teacher-assigned work or assignments, resulting in a satisfactory final overview. However, their proficiency in drawing accurate conclusions from problem identification remains an area of weakness.

Learning Outcomes

Cognitive and psychomotor learning outcomes data were acquired by means of observing learning activities within the Problem-Based Learning (PBL) model, with a focus on assessing the achievement of predetermined indicators. The cognitive learning outcomes encompassed the same indicators as critical thinking, and they were examined as follows (see Table 3).

Table 3. Cognitive Learning Outcomes Cycle I

Test Type	Score
Cognitive Learning Outcomes	73.6
Accomplished	66.7% (18 Students)
Not yet accomplished	33.3% (9 Students)

Based on the data presented in Table 3 during Cycle I, the cognitive learning outcomes of the students yielded an average score of 73.6, with a completeness rate of 66.7%. These findings indicate that the cognitive learning outcomes in Cycle I were deemed satisfactory. However, in terms of classical completeness, only 18 out of 27 students passed, while 9 students did not meet the passing criteria, highlighting that the minimum completeness requirements for the class were still considered inadequate. The evaluation of the psychomotor aspects was conducted in each cycle through practical tasks involving the creation of infographics and presentations on the storage of administrative documents for facilities and infrastructure.

The assessment of psychomotor learning outcomes was based on observations of data related to work preparation, work execution, and work results. The assessment revealed the following: Regarding work preparation, students demonstrated sufficient proficiency in adequately preparing the required equipment. However, when it came to the work execution indicator, students showed limited ability in researching the topics to be used for creating infographics. Nonetheless, they exhibited reasonable competence in problem identification, discussion delivery, and compiling presentation materials in accordance with the assigned topic. One area that lacked improvement was their adherence to time discipline.

In terms of work results, students demonstrated the ability to identify case studies, create comprehensive infographics, and practice the filing system adequately. Among the indicators, the aspect of identifying case studies received the highest score of 80.4, indicating that students had a good understanding of the given case study, enabling them to accurately identify the associated problems. Conversely, the implementation of work in terms of time discipline received the lowest score of 65.6, indicating that students struggled to manage their allotted time effectively, thus hindering task completion. Overall, the psychomotor learning outcomes of the students in Cycle I exhibited an average value of 74.1, with a completeness rate of 74.1%.

Reflection

In Cycle I, the utilization of the Problem-Based Learning (PBL) model, facilitated by genially media, was employed for the purpose of learning. Following the implementation of this approach, data analysis revealed that both teacher and learner activities achieved a satisfactory level of success. The findings demonstrate that the PBL model effectively stimulates students' critical thinking abilities. Specifically, four out of the six critical thinking indicators employed received satisfactory scores. However, two indicators, namely inference and situation, displayed lower performance levels. Additionally, the learning outcomes of students in Cycle I received sufficient scores; nevertheless, they fell short of meeting the criteria for classical completeness, with only 66.7% of the class members achieving

the desired level. To enhance the success of teacher and learner activities, as well as to improve critical thinking skills and cognitive and psychomotor learning outcomes, the researchers conducted a reflective analysis. The aim was to identify and address the existing deficiencies in order to attain the desired indicators in Cycle II.

Cycle II—Accomplishment of Teacher and Students Activity

In Cycle II, the teacher activities achieved an average score of 95.83%. The observation results indicate that the teacher's implementation of PBL learning was highly commendable, as most of the PBL learning components were effectively incorporated into the instructional process, ranging from the initial activities to the conclusion of the learning session. Furthermore, the student learning activities received an average score of 91.77%. The observations conducted during Cycle II revealed that the students' engagement with the learning material and their ability to actively participate in the PBL model, aided by the use of Genially media, were exceptional. These findings suggest that a majority of the students comprehended the subject matter and successfully followed the learning process.

Critical Thinking Ability

The outcomes of cycle II revealed a notable enhancement in critical thinking abilities. Among the indicators measured, the overview indicator attained the highest score of 94, whereas the situation indicator recorded the lowest score of 80. This suggests that students demonstrated a commendable proficiency in providing comprehensive overviews, albeit exhibiting slight room for improvement in gathering information pertinent to the given problems. Nevertheless, the situation indicator scores already indicated a reasonably satisfactory level of competence.

Learning Outcomes

During Cycle II, there was a notable improvement in the learning outcomes of the students. The cognitive learning outcomes achieved a score of 87.96, indicating a high level of comprehension and problem-solving skills, with a completeness rate of 96.3%. Among the indicators assessed in Cycle II, the aspect of studying topics to create infographics and identifying problems received the highest score of 100. This outcome suggests that students found it relatively easy to grasp the given topics and identify associated problems. On the other hand, the implementation of work regarding the compilation of presentation materials according to the topic obtained the lowest score of 74.4. This result indicates that students faced challenges in preparing presentation materials, reflecting some confusion in this particular aspect. The average value of students' psychomotor learning outcomes in Cycle II was 90.18, demonstrating a commendable level of proficiency in performing physical tasks, with a completeness rate of 85.2%.

Reflection

In Cycle II, the effectiveness of teacher and learner activity actions reached a highly commendable level. Notably, there was a notable improvement in students' critical thinking abilities across all indicators. Moreover, the cognitive and psychomotor learning outcomes of the students displayed significant progress, with an

achievement rate of 96.3% among the total class members. These outcomes provide compelling evidence to support the effectiveness and significance of the Project-Based Learning (PBL) model, aided by the utilization of genially media, in enhancing the success of teacher and learner activity actions, fostering critical thinking skills, and improving overall learning outcomes. The graphs and tables presented below illustrate comprehensive comparisons across all variables. The development of the success of teacher activity actions over two cycles is presented in Figure 1.

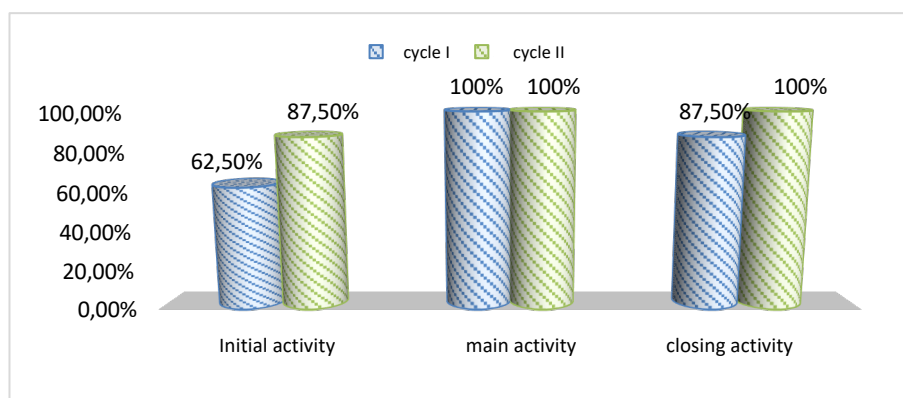


Figure 1. Teacher Activity Accomplishment

Tabulation of the success of learner activity actions for two cycles obtained an increase in learner activity from cycle I to cycle II by 9.47%. The development of critical thinking skills over two cycles is presented in Figure 2. The development of cognitive learning outcomes over two cycles is presented in Figure 3. Tabulation of psychomotor learning outcomes over two cycles shows an increase in psychomotor learning outcomes from cycle I to cycle II of 16.08%.

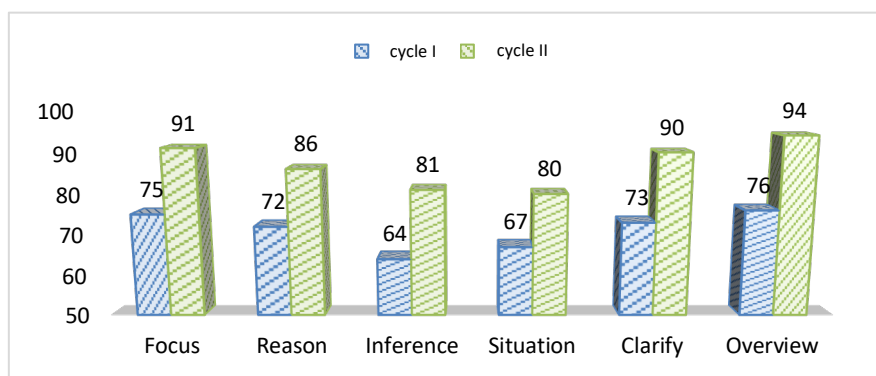


Figure 2. Critical Thinking Ability

Feedback from Students

In this study, learner feedback is presented to show the impact of using the PBL model with the help of genially media. From the learners' responses, it can be seen that learners feel the positive impact of using the PBL model with the help of genially media. The learners feel that learning becomes more conducive and fun, which encourages them to pay more attention to the teacher's explanations. In addition, the PBL model also has an impact on students' critical thinking skills, where it becomes easier for students to understand and analyze the case studies given.

Although there were some initial barriers to the use of ingenious media, this did not become a barrier to learning.

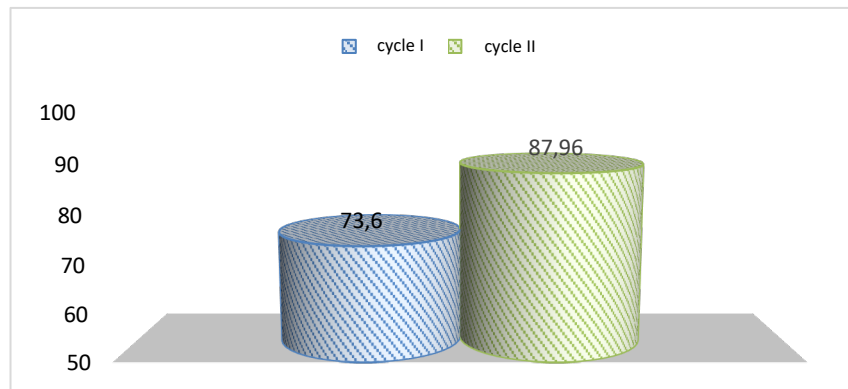


Figure 3. Cognitive Learning Outcomes

Discussion

The study findings demonstrate that the implementation of the Problem-Based Learning (PBL) model maximized the learning process, as evident from the high marks achieved by both teachers and students. Notably, students' engagement in learning activities showed a significant increase from Cycle I to Cycle II. The utilization of PBL had a positive influence on learners' activities by integrating theoretical concepts with practical applications, thereby enhancing their motivation to learn (Silva et al., 2018; Siregar & Simatupang, 2020). During the learning process, students exhibited a genuine passion for acquiring knowledge and demonstrated effective problem-solving abilities through meaningful discussions (Cetin et al., 2019; Prasistayanti et al., 2019). Moreover, learners actively participated in learning activities, while the implementation of the PBL approach was effectively carried out (Sakir & Kim, 2020; Triandi et al., 2020).

Furthermore, the PBL model was found to augment students' learning activities and facilitate academic achievement (Fidan & Tuncel, 2019; Suhaimi & Nasidawati, 2020). Additionally, teacher involvement in the learning process using PBL increased from Cycle I to Cycle II. PBL necessitates teachers to adopt the role of facilitators who assist students in problem-solving (Golightly, 2021; Woa et al., 2018). Teachers play a crucial role in providing students with autonomy and control over their learning within a collaborative environment (Levin, 2001; Yuniar et al., 2022). The PBL approach is particularly suitable for empowering teachers to optimize learning activities (Ali, 2019). Moreover, the PBL model, when combined with online learning using genially media, enhanced students' enthusiasm for learning, as they became more engaged in classroom practice (Rosmilasari & Adoe, 2021; Savin-Baden & Wilkie, 2006).

The incorporation of genially media in PBL supported effective learning activities and fostered students' problem-solving skills (Abdullah et al., 2021; Dita et al., 2021). The research conducted by Maqbullah et al. (2018) and Pebriyani & Pahlevi (2020) demonstrated significant improvements in critical thinking skills from Cycle I to Cycle II. This improvement can be attributed to the reflective stage that occurs after Cycle I, where the results are analyzed to identify areas for improvement and provide guidelines for actions in Cycle II. The process of reflection

contributed to the enhancement of critical thinking skills among students in Cycle II (Maqbullah et al., 2018; Pebriyani & Pahlevi, 2020). The utilization of the Problem-Based Learning (PBL) model, supported by genial media and internet technology, proved to be effective in enhancing students' critical thinking abilities (Hussin et al., 2018; Sari & Ma'rifah, 2020).

PBL facilitates the development of higher-order thinking skills among learners, as the case studies presented in this approach require in-depth analysis (Amin et al., 2020; Zhou, 2018). Additionally, integrating creative media into the PBL model encourages students to engage in exploratory thinking to solve problems (Cabrera-Solano, 2022; Einstein et al., 2022). The critical thinking indicators employed in this study include focus, reasoning, inference, situational analysis, clarification, and overview. Observations revealed that in Cycle I, learners demonstrated a satisfactory level of focus in comprehending the given problems. Furthermore, they exhibited competence in providing well-reasoned responses, utilizing relevant information, and offering detailed explanations. The learners achieved the highest scores in the overview indicator, indicating their ability to provide a comprehensive and accurate assessment of their compiled answers (Cruz et al., 2018; Rusmansyah et al., 2020).

The attainment of these critical thinking ability indicators can be attributed to the implementation of the PBL model as the instructional approach employed by the teacher. Notably, the PBL model exerted a significant influence on the improvement of critical thinking skills (Noer & Gunowibowo, 2018; Seibert, 2021). Furthermore, the utilization of interactive learning media, specifically Genially, contributed to the enhancement of students' critical thinking skills (Jannah & Atmojo, 2022; Khoirun Ni'mah et al., 2022). Nevertheless, students encountered difficulties in formulating accurate conclusions in line with the given problem. This can be attributed to their limited familiarity with the Problem-Based Learning (PBL) model facilitated by Genially, requiring additional time for adaptation to meet the stipulated deadline (Argusni & Sylvia, 2019; Mayawati et al., 2020). However, in Cycle II, a noticeable improvement was observed in students' critical thinking abilities.

Learners demonstrated increased focus, the ability to provide relevant justifications, and draw correct conclusions. This positive outcome can be attributed to the students' adaptation to the PBL model, aided by the teacher's adept implementation of suitable strategies during the learning process (Amaliyah, 2022; Kistian, 2019). Additionally, students exhibited the capability to explain their responses comprehensively and systematically rectify problem-solving outcomes from inception to resolution (Lapuz & Fulgencio, 2020; Pratiwi & Setyaningtyas, 2020). Nonetheless, in Cycle II, the aspect with the lowest score was the students' utilization of appropriate information pertinent to the provided case study. This deficiency stemmed from the students' perception that they required more time for problem analysis, despite the imposed time constraints (Septian & Komala, 2019; Astuti, 2019).

In the second cycle, students demonstrated significantly higher learning outcomes compared to the first cycle. This improvement can be attributed to the implementation of different teaching approaches. Teachers in the second cycle carefully analyzed and reflected upon the shortcomings observed in the first cycle, which allowed them to focus their efforts on addressing those weaknesses

(Setiawati & Zuniati, 2020; Susilowati, 2018). As a result, students achieved better learning outcomes during the second cycle. The utilization of the Problem-Based Learning (PBL) model proved effective in enhancing students' motivation and learning outcomes (Pambudi, 2019; Robiyanto, 2021). PBL emphasizes the development of critical thinking and problem-solving skills among students (Anggraeni et al., 2018; Malmia et al., 2019). The cognitive learning outcome indicators employed in this study align with the indicators of critical thinking. The incorporation of the PBL model into teaching and learning activities within vocational schools was found to enhance students' cognitive learning outcomes (Kusnandar, 2019; Moallem, 2019).

Regarding psychomotor learning outcomes, the indicators encompassed work preparation, execution, and results. Throughout the utilization of the Genially media platform, students actively engaged in group discussions to resolve the case studies provided by the teacher, leading to improved learning outcomes (Fatma & Ichsan, 2022; Kolmos et al., 2020). Observations revealed that students exhibited proficiency in preparing for and executing work, resulting in satisfactory work outcomes. Notably, the learners' psychomotor learning outcomes witnessed a notable increase following the second cycle of learning. Learners displayed meticulous preparation, proficient task execution, and substantial improvement in the quality of their work (Husnidar & Hayati, 2021; Tambunan et al., 2018). These findings align with the research conducted by Musyadad and Somnaikubun, which demonstrated the positive influence of Problem-Based Learning on student learning outcomes in both cognitive and psychomotor domains (Musyadad et al., 2019; Somnaikubun et al., 2022).

Upon the implementation of problem-based learning using Genially media, students provided feedback indicating that student-centered learning was challenging yet rewarding, as it allowed for a more comprehensive exploration of their individual abilities. An effective teacher not only imparts knowledge but also encourages students to seek knowledge independently (Mayasari, 2022; Meilia & Murdiana, 2019). The utilization of Genially as interactive learning media was also perceived as enjoyable by students, as it was their first experience with this platform in learning activities. The interactive nature of Genially contributed to increased enthusiasm for learning, consequently maximizing learning outcomes (Enstein et al., 2022b; Ni'mah et al., 2022a). However, learners faced certain difficulties, such as meeting deadlines at each stage, which often created time-related pressure. Additionally, students who did not study the material prior to the learning activities lagged behind their classmates who had prepared in advance. In this study, problem-based learning was implemented through both individual and group assignments, enabling students to support and assist one another, thereby facilitating the achievement of learning objectives (Djononiarjo, 2020)

CONCLUSION

The present study aimed to elucidate the implementation of the problem-based learning (PBL) model with the assistance of Genially, focusing on its effects on critical thinking and student learning outcomes. The study sought to draw several

conclusions in response to the formulated problem. Firstly, the implementation of the problem-based learning model with Genially media in the subject of Automation of Management of Facilities and Infrastructure for twelfth-grade students of Office Management Automation at Al-Ishlahiyah Singosari Integrated Vocational School was successfully executed. Secondly, there was a noteworthy enhancement in both student and teacher engagement during the utilization of the problem-based learning model with Genially media. Thirdly, the problem-based learning model was found to be effective in enhancing students' critical thinking skills and improving their learning outcomes.

However, the study identified that certain indicators of critical thinking skills, particularly inference and situation indicators, remained relatively low. This was primarily attributed to the limited research time, which did not allow students sufficient opportunity to fully adapt to the applied learning model. Therefore, it is recommended that future researchers allocate a longer duration for their investigations in order to obtain more comprehensive and optimal outcomes. It is worth noting that the research solely examined the application of the PBL model within the field of Office Management Automation. Consequently, it is advisable to extend this approach to other fields of study in future research endeavors. Genially media demonstrated accessibility for all users and garnered a positive response in this study, significantly impacting the classroom atmosphere. As a result, teachers are encouraged to acquire proficiency in Genially, as it serves as a valuable alternative learning medium. The present research concluded that PBL effectively enhances critical thinking skills and student learning outcomes. Hence, it is recommended that future studies explore additional variables, such as creativity, innovation, and learning independence, in conjunction with the implementation of PBL. This would contribute to further advancements in educational practices and pedagogical approaches.

REFERENCES

- Abdullah, A. H., Neo, T. K., & Low, J. H. (2021). *Weak and strong ties and its connection to experts' problem-solving styles in scaffolding students' PBL activities on social media*. *F1000Research*, 10, 1–21. <https://doi.org/10.12688/f1000research.73210.2>
- Abdurrokhman, D., Hamimudin, D., & Rostikawati, Y. (2023). The use of Genially assisted problem based learning (PBL) methods in Class VIII students' learning to write explanation texts. *JLER Journal of Language Education Research*, 6(1), 41–63.
- Ahmatika, D. (2017). Peningkatan kemampuan berpikir kritis siswa dengan pendekatan inquiry/discovery. *Euclid*, 3(1), 394–403. <https://doi.org/10.33603/e.v3i1.324>
- Al-Fikry, I., Yusrizal, Y., & Syukri, M. (2018). Pengaruh model problem based learning terhadap kemampuan berpikir kritis peserta didik pada materi Kalor. *Jurnal Pendidikan Sains Indonesia*, 6(1), 17–23. <https://doi.org/10.24815/jpsi.v6i1.10776>

- Alexander, F., & Pono, F. R. (2019). Penerapan metode pembelajaran kooperatif tipe examples non examples untuk meningkatkan hasil belajar kognitif siswa. *Jurnal Ilmiah Religiosity Entity Humanity (JIREH)*, 1(2), 110–126. <https://doi.org/10.37364/jireh.v1i2.21>
- Ali, S. S. (2019). *Problem based learning: A student-centered approach. English Language Teaching*, 12(5), 73. <https://doi.org/10.5539/elt.v12n5p73>
- Amaliyah, S. (2022). Peningkatan Keaktifan peserta didik kelas ix smp dengan penerapan model problem based learning (PBL) pada materi Bangun Ruang Sisi Lengkung. *Postulat: Jurnal Inovasi Pendidikan Matematika*, 3(1), 50. <https://doi.org/10.30587/postulat.v3i1.4316>
- Amanda, F. F., Sumitro, S. B., Lestari, S. R., & Ibrohim. (2022). *The correlation of critical thinking and concept mastery to problem-solving skills: The role of complexity science-problem based learning model. Pedagogika*, 146(2), 80–94. <https://doi.org/10.15823/p.2022.146.4>
- Amin, S., Utaya, S., Bachri, S., Sumarmi, & Susilo, S. (2020). Effect of problem-based learning on critical thinking skills and environmental attitude. *Journal for the Education of Gifted Young Scientists*, 8(2), 743–755. <https://doi.org/10.17478/jegys.650344>
- Aminullah. (2018). Implementasi problem based learning untuk meningkatkan kemampuan berpikir kritis dan hasil belajar siswa. *Prosiding Seminar Nasional Lembaga Penelitian Dan Pendidikan (LPP) Mandala*, 1–9.
- Anggraeni, H., Rahayu, S., Rusdi, R., & Ichsan, I. Z. (2018). Pengaruh reciprocal teaching dan problem based learning terhadap kemampuan berpikir kritis peserta didik SMA pada materi sistem reproduksi. *Biota*, 11(1), 77–95. <https://doi.org/10.20414/jb.v11i1.84>
- Argusni, R., & Sylvia, I. (2019). Implementasi pelaksanaan model problem based learning untuk meningkatkan kemampuan problem solving siswa kelas XI IIS SMAN 16 Padang. *Jurnal Sikola: Jurnal Kajian Pendidikan Dan Pembelajaran*, 1(1), 52–59. <https://doi.org/10.24036/sikola.v1i1.9>
- Aufa, M. N., Rusmansyah, R., Hasbie, M., Jaidie, A., & Yunita, A. (2021). The effect of using e-module model problem based learning (PBL) based on wetland environment on critical thinking skills and environmental care Attitudes. *Jurnal Penelitian Pendidikan IPA*, 7(3), 401–407. <https://doi.org/10.29303/jppipa.v7i3.732>
- Aulia, L. N., Susilo, S., & Subali, B. (2019). Upaya peningkatan kemandirian belajar siswa dengan model problem-based learning berbantuan media Edmodo. *Jurnal Inovasi Pendidikan IPA*, 5(1), 69–78. <https://doi.org/10.21831/jipi.v5i1.18707>
- Bano, M., Ahda, V., & Jaiswal, Y. (2022). Summary and analysis of teaching methods for cultivating students' critical thinking ability in elementary education. *Journal of Educational Research and Policies*, 4(8), 116–119. [https://doi.org/10.53469/jerp.2022.04\(08\).25](https://doi.org/10.53469/jerp.2022.04(08).25)
- Cabrera-Solano, P. (2022). Game-based learning in higher education: the pedagogical effect of Genially Games in English as a Foreign Language Instruction. *International Journal of Educational Methodology*, 8(4), 719–729. <https://doi.org/10.12973/ijem.8.4.719>

- Cetin, Y., Mirasyedioglu, S., & Cakiroglu, E. (2019). An inquiry into the underlying reasons for the impact of technology enhanced problem-based learning activities on students' attitudes and achievement. *Eurasian Journal of Educational Research*, 2019(79), 191–208. <https://doi.org/10.14689/ejer.2019.79.9>
- Choiriya, I. N., Nurdita, E., & Chuseng, A. (2019). The effect of problem based learning on critical thinking ability in mathematics education. *Bioedukasi*, 17(1), 25–29. <https://doi.org/10.1088/1742-6596/1157/4/042063>
- Cruz, G., Payan-Carreira, R., & Dominguez, C. (2018). Critical thinking education in the portuguese higher education institutions: A systematic review of educational practices. *Revista Lusofona de Educacao*, 38(38), 43–61. <https://doi.org/10.24140/issn.1645-7250.rle38.03>
- Dabbagh, N. (2019). *Effects of PBL on critical thinking skills*. In *The Wiley Handbook of Problem-Based Learning* (pp. 135–156).
- Dita, P. P. S., Murtono, Slamet, U., & Sekar, D. A. (2021). Implementation of problem based learning (PBL) on interactive learning media. *Journal of Technology and Humanities*, 2(2), 24–30.
- Enstein, J., Bulu, V. R., & Nahak, R. L. (2022). Pengembangan media pembelajaran game edukasi bilangan pangkat dan akar menggunakan Genially. *Jurnal Jendela Pendidikan*, 2(1), 101–109.
- Fatma, N., & Ichsan. (2022). Penerapan media pembelajaran berbasis Genially untuk Meningkatkan Hasil Belajar IPA di SD Muhammadiyah. 3(2), 50–59. <https://doi.org/10.47766/ga.v3i2.955>
- Fidan, M., & Tuncel, M. (2019). Integrating augmented reality into problem based learning: The effects on learning achievement and attitude in physics education. *Computers and Education*, 142(July), 103635. <https://doi.org/10.1016/j.compedu.2019.103635>
- Golightly, A. (2021). Self- and peer assessment of preservice geography teachers' contribution in problem-based learning activities in geography education. *International Research in Geographical and Environmental Education*, 30(1), 75–90. <https://doi.org/https://doi.org/10.1080/10382046.2020.1744242>
- Hadi Santosa, F., Umasih, U., & Sarkadi, S. (2018). Pengaruh model pembelajaran dan kemampuan berpikir kritis terhadap hasil belajar sejarah siswa di SMA Negeri 1 Pandeglang. *JTP - Jurnal Teknologi Pendidikan*, 20(1), 13–27. <https://doi.org/10.21009/jtp.v20i1.6777>
- Handayani, A., & Koeswanti, H. D. (2021). Meta-analisis model pembelajaran problem based learning (PBL) untuk meningkatkan kemampuan berpikir kreatif. *Jurnal Basicedu*, 5(3), 1349–1355.
- Handayani, E. S., & Subakti, H. (2020). Pengaruh disiplin belajar terhadap hasil belajar Bahasa Indonesia di Sekolah Dasar. *Jurnal Basicedu*, 5(1), 151–164. <https://doi.org/10.31004/basicedu.v5i1.633>
- Husnidar, & Hayati, R. (2021). Jurnal Pendidikan Matematika dan Sains. *ASIMETRIS: Jurnal Pendidikan Matematika Dan Sains*, 2(2), 67–72.
- Hussin, W. N. T. W., Harun, J., & Shukor, N. A. (2018). Problem based learning to enhance students critical thinking skill via online tools. *Asian Social Science*, 15(1), 14. <https://doi.org/10.5539/ass.v15n1p14>

- Ismail, N. S., Harun, J., Zakaria, M. A. Z. M., & Salleh, S. M. (2018). The effect of Mobile problem-based learning application DicScience PBL on students' critical thinking. *Thinking Skills and Creativity*, 28(April), 177–195. <https://doi.org/10.1016/j.tsc.2018.04.002>
- Jannah, D. R. N., & Atmojo, I. R. W. (2022). Media digital dalam memberdayakan kemampuan berpikir kritis abad 21 pada pembelajaran IPA di Sekolah Dasar. *Jurnal Basicedu*, 6(1), 1064–1074. <https://doi.org/10.31004/basicedu.v6i1.2124>
- Kahar, M. I., Cika, H., Nur Afni, & Nur Eka Wahyuningsih. (2021). Pendidikan Era revolusi industri 4.0 menuju era society 5.0 di masa pandemi Covid 19. *Moderasi: Jurnal Studi Ilmu Pengetahuan Sosial*, 2(1), 58–78. <https://doi.org/10.24239/moderasi.vol2.iss1.40>
- Kartika, I. M., Angga Mahendra, P. R., & Awa, V. (2020). Penerapan pembelajaran problem based learning untuk meningkatkan ketrampilan berpikir kritis siswa pada mata pelajaran PPKn. *Jurnal Locus Delicti*, 1(1), 1–10. <https://doi.org/10.23887/jld.v1i1.359>
- Kawuri, M. Y. R. T., Ishafit, I., & Fayanto, S. (2019). Efforts to improve the learning activity and learning outcomes of physics students with using a problem-based learning model. *IJIS Edu: Indonesian Journal of Integrated Science Education*, 1(2). <https://doi.org/10.29300/ijisedu.v1i2.1957>
- Khasani, R., Ridho, S., & Subali, B. (2019). Identifikasi Kemampuan Berpikir Kritis Siswa SMP Pada Materi Hukum Newton. *Jurnal Penelitian Pendidikan IPA*, 5(2), 165. <https://doi.org/10.29303/jppipa.v5i2.192>
- Khoirun Ni'mah, N., Warsiman, W., & Hermiati, T. (2022). Upaya Meningkatkan minat belajar siswa melalui media genially dalam pembelajaran daring Bahasa Indonesia Pada Siswa Kelas X Sma Negeri 5 Malang. *Jurnal Metamorfosa*, 10(1), 1–10. <https://doi.org/10.46244/metamorfosa.v10i1.1731>
- Kistian, A. (2019). penerapan model pembelajaran problem based learning (pbl) dalam meningkatkan hasil belajar siswa kelas IV SD Negeri Ujong Tanjong Kabupaten Aceh Barat. *Genta Mulia: Jurnal Ilmiah Pendidikan*, X(1), 92–104.
- Kolmos, A., Holgaard, J. E., & Clausen, N. R. (2020). Progression of student self-assessed learning outcomes in systemic PBL. *European Journal of Engineering Education*, 1–23. <https://doi.org/10.1080/03043797.2020.1789070>
- Kusnandar, D. (2019). Pengaruh model problem based learning terhadap hasil belajar kognitif dan motivasi belajar Ipa. *Pendidikan Islam, Sains, Sosial, dan Budaya*, 1(1), 17–30.
- Lapuz, A. M., & Fulgencio, M. N. (2020). Improving the critical thinking skills of secondary school students using problem-based learning. *International Journal of Academic Multidisciplinary Research*, 4(1), 1–7. www.ijeais.org/ijamr
- Levin, B. B. (2001). *Energizing teacher education and professional development with problem-based learning*. ASCD.
- Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, 45(December 2021). <https://doi.org/10.1016/j.tsc.2022.101069>

- Malmia, W., Makatita, S. H., Lisaholit, S., Azwan, A., Magfirah, I., Tinggapi, H., & Umanailo, M. C. B. (2019). Problem-based learning as an effort to improve student learning outcomes. *International Journal of Scientific and Technology Research*, 8(9), 1140–1143.
- Maqbullah, S., Sumiati, T., & Muqodas, I. (2018). Penerapan model problem based learning (pbl) untuk meningkatkan kemampuan berpikir kritis siswa pada pembelajaran Ipa di Sekolah Dasar. *Metodik Didaktik*, 13(2), 106–112. <https://doi.org/10.17509/md.v13i2.9500>
- Mayawati, M., Mulbasari, A. S., & Nurjannah, N. (2020). Upaya meningkatkan hasil belajar peserta didik melalui model problem based learning di masa pandemi. *Indiktika: Jurnal Inovasi Pendidikan Matematika*, 3(1), 81–93. <https://doi.org/10.31851/indiktika.v3i1.5073>
- Men, F. E., Gunur, B., Jundu, R., & Raga, P. (2020). Critical thinking profiles of junior high school students in solving plane geometry problems based on cognitive style and gender. *Indonesian Journal of Science and Mathematics Education*, 3(2), 237–244. <https://doi.org/10.24042/ijsme.v3i2.5955>
- Moallem, M. (2019). *Effects of PBL on learning outcomes, knowledge acquisition, and higher - order thinking skills*. In *The Wiley Handbook of Problem-Based Learning* (pp. 107–133).
- Monalisa, C., Ahda, Y., & Fitria, Y. (2019). Critical thinking skill improvement using problem based learning (PBL) model of 4th grade students of elementary school. *International Journal of Science and Research (IJSR)*, 8(2), 429–432. <http://www.ijsr.net/archive/v8i2/ART20194984.pdf>
- Musyadad, V. F., Supriatna, A., & Parsa, S. M. (2019). Penerapan model pembelajaran problem based learning dalam meningkatkan hasil belajar siswa pada pelajaran IPA pada konsep perubahan lingkungan fisik dan pengaruhnya terhadap daratan. *Jurnal Tahsinia Jurnal Karya Umum dan Ilmiah*, 1(1), 1–13.
- Nirahua, J., Taihuttu, J., & Sopacua, V. (2020). Pengembangan bahan ajar berbasis blended learning dan critical thinking skill pada mata kuliah astrofisika dalam menyongsong era revolusi industri 4.0. *Jambura Physics Journal*, 2(1), 24–36. <https://doi.org/10.34312/jpj.v2i1.6869>
- Noer, S. H., & Gunowibowo, P. (2018). Efektivitas problem based learning ditinjau dari kemampuan berpikir kritis dan representasi Matematis. *Jurnal Penelitian dan Pembelajaran Matematika*, 11(2).
- Nurjannah, N., & Khatimah, H. (2022). Upaya Meningkatkan hasil belajar mata pelajaran sejarah siswa melalui model pembelajaran example dan non example pada siswa SMA. *Ainara Journal (Jurnal Penelitian Dan PKM Bidang Ilmu Pendidikan)*, 3(1), 36–41. <https://doi.org/10.54371/ainj.v3i1.112>
- Nurrohma, R. I., & Adistana, G. A. Y. P. (2021). Penerapan model pembelajaran problem based learning dengan media e-learning melalui aplikasi Edmodo pada Mekanika Teknik. *Edukatif: Jurnal Ilmu Pendidikan*, 3(4), 1199–1209.
- Pambudi, G. W. (2019). Implementasi model problem based learning untuk meningkatkan motivasi dan hasil belajar pemeliharaan mesin kendaraan ringan siswa kelas XI Od SMK Yappi Wonosari. *Jurnal Pendidikan Vokasi Otomotif*, 2(1), 67–84. <https://doi.org/10.21831/jpvo.v2i1.28393>
- Pebriyani, E. P., & Pahlevi, T. (2020). Pengaruh model pembelajaran problem based learning (PBL) terhadap kemampuan berpikir kritis dan hasil belajar peserta

- didik pada mata pelajaran Kearsipan Kelas X OTKP Di SMK Negeri 1 Sooko Mojokerto. *Jurnal Pendidikan Administrasi Perkantoran (JPAP)*, 8(1), 47–55. <https://doi.org/10.26740/jpap.v8n1.p47-55>
- Prasistayanti, N. W. N., Santyasa, I. W., & Sukra Warpala, I. W. (2019). Pengaruh desain e-learning terhadap hasil belajar dan keterampilan berpikir kreatif siswa dalam mata pelajaran pemrograman pada siswa Smk. *Kwangsan: Jurnal Teknologi Pendidikan*, 7(2), 138. <https://doi.org/10.31800/jtp.kw.v7n2.p138-155>
- Pratiwi, E. T., & Setyaningtyas, E. W. (2020). Kemampuan berpikir kritis siswa melalui model pembelajaran problem based learning dan model pembelajaran project based learning. *Jurnal Basicedu*, 4(2), 379–388. <https://doi.org/10.31004/basicedu.v4i2.362>
- Putri, D. A. H., Fauziah, N., & Wati, W. W. (2022). Analisis effect size pengaruh model problem based learning terhadap keterampilan berpikir kritis dan pemecahan masalah dalam pembelajaran sains. *ORBITA: Jurnal Kajian, Inovasi Dan Aplikasi Pendidikan Fisika*, 8(2), 205. <https://doi.org/10.31764/orbita.v8i2.10295>
- Rahmat, E. (2018). Penerapan model pembelajaran problem based learning (PBL) untuk meningkatkan prestasi belajar siswa. *Jurnal Penelitian Pendidikan*, 18(2), 144–159. <https://doi.org/10.17509/jpp.v18i2.12955>
- Robiyanto, A. (2021). Pengaruh model brain based learning terhadap hasil belajar siswa. *MAHAGURU: Jurnal Pendidikan Guru Sekolah Dasar*, 2(1), 114–121. <https://doi.org/10.51836/jedma.v1i2.155>
- Rosmilasari, D. M. A. R., & Adoe, D. P. (2021). Design and implementation of online problem based learning (PBL) assisted by innovative media to improve elementary school student learning outcomes. *Journal of Education Technology*, 4(4), 456. <https://doi.org/10.23887/jet.v5i1.29929>
- Rusmansyah, Yuanita, L., Ibrahim, M., Isnawati, Rizkiana, F., & Kusuma, A. E. (2020). Effect of scientific critical thinking model to train critical thinking skills and student self efficacy. *Journal of Physics: Conference Series*, 1422(1). <https://doi.org/10.1088/1742-6596/1422/1/012015>
- Sakir, N. A. I., & Kim, J. G. (2020). Enhancing students' learning activity and outcomes via implementation of problem-based learning. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(12), em1925. <https://doi.org/10.29333/ejmste/9344>
- Sari, W. P., & Ma'rifah, D. R. (2020). Pengembangan Lkpd Mobile Learning Berbasis Android Dengan Pbl untuk meningkatkan critical thinking materi lingkungan. *Jurnal Pendidikan Biologi*, 11(2), 49. <https://doi.org/10.17977/um052v11i2p49-58>
- Savin-Baden, M., & Wilkie, K. (2006). *EBOOK: Problem-based Learning Online*. McGraw-Hill Education (UK).
- Seibert, S. A. (2021). Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance. *Teaching and Learning in Nursing*, 16(1), 85–88. <https://doi.org/10.1016/j.teln.2020.09.002>
- Septian, A., & Komala, E. (2019). Kemampuan koneksi matematik dan motivasi belajar siswa dengan menggunakan model problem-based learning (Pbl) Berbantuan Geogebra di Smp. *Prisma*, 8(1), 1. <https://doi.org/10.35194/jp.v8i1.438>

- Setiawati, I., & Zuniati, M. (2020). Supervisi korektif untuk menemukan kekurangan – kekurangan guru kelas dalam melaksanakan pembelajaran di SD Negeri 173105 Tarutung. *Attractive : Innovative Education Journal*, 2(2), 1–13.
- Sharma, S., Saragih, I. D., Tarihoran, D. E. T. A. U., & Chou, F. H. (2023). Outcomes of problem-based learning in nurse education: A systematic review and meta-analysis. *Nurse Education Today*, 120(October 2022), 105631. <https://doi.org/10.1016/j.nedt.2022.105631>
- Shofwani, S. A., & Rochmah, S. (2021). Penerapan Problem based learning untuk meningkatkan minat dan hasil belajar manajemen operasional di masa pandemi Covid-19. *Jurnal Educatio FKIP UNMA*, 7(2), 439–445. <https://doi.org/10.31949/educatio.v7i2.1074>
- Silva, A. B. Da, Bispo, A. C. K. de A., Rodriguez, D. G., & Vasquez, F. I. F. (2018). Problem-based learning: A proposal for structuring PBL and its implications for learning among students in an undergraduate management degree program. *Revista de Gestao*, 25(2), 160–177. <https://doi.org/10.1108/REG-03-2018-030>
- Siregar, W. D., & Simatupang, L. (2020). Pengaruh model pembelajaran PBL terhadap aktivitas belajar dan hasil belajar siswa pada materi Asam Basa. *Jurnal Inovasi Pembelajaran Kimia*, 2(2), 91. <https://doi.org/10.24114/jipk.v2i2.19571>
- Somnaikubun, D., Paat, W. R. L., & Palilingan, V. R. (2022). Penerapan model problem based learning untuk meningkatkan hasil belajar simulasi dan komunikasi digital siswa SMK. *EduTIK: Jurnal Pendidikan Teknologi Informasidan Komunikasi*, 2(2), 295–307. <https://ejournal.unima.ac.id/index.php/edutik/article/view/3293>
- Sudarmiani, S. (2020). The development of economic learning model through CTL (Contextual Teaching and Learning) to promote students' critical thinking skill. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, 3(2), 714–723. <https://doi.org/10.33258/birle.v3i2.900>
- Suhaimi, & Nasidawati. (2020). Meningkatkan aktivitas belajar siswa materi bangun ruang menggunakan kombinasi model problem based learning, Numbered Head Together dan Course Review Horay dengan media bangun ruang kelas V/C SDN Handil Bakti Kabupaten Barito Kuala. *LENTERA Jurnal Ilmiah Kependidikan*, 15(2), 74–86.
- Susilowati, D. (2018). Penelitian tindakan kelas (Ptk) solusi alternatif problematika pembelajaran. *Edunomika*, 2(1), 36–46.
- Tambunan, L., Rusdi, R., & Miarsyah, M. (2018). Effectiveness of problem based learning models by using e-learning and learning motivation toward students learning outcomes on subject circulation systems. *Indonesian Journal of Science and Education*, 2(1), 96. <https://doi.org/10.31002/ijose.v2i1.598>
- Tanjung, A. W. S., Bektiarso, S., & Lesmono, A. D. (2023). Pengaruh model pembelajaran berbasis masalah disertai sumber belajar lingkungan terhadap hasil belajar Fisika dan kemampuan berpikir kritis peserta didik. *JPF (Jurnal Pendidikan Fisika) Universitas Islam Negeri Alauddin Makassar*, 11(1), 67–75.
- Thorndahl, K. L., & Stentoft, D. (2020). Thinking critically about critical thinking and problem-based learning in higher education: A scoping review. *Interdisciplinary Journal of Problem-Based Learning*, 14(1), 1–21.

- Tri Pudji Astuti. (2019). Model problem based learning dengan mind mapping dalam pembelajaran IPA Abad 21. *Proceeding of Biology Education*, 3(1), 64–73. <https://doi.org/10.21009/pbe.3-1.9>
- Triandi, D., Nuryani, P., & Djumhana, N. (2020). Penerapan model pembelajaran PBL (Problem Based Learning) untuk meningkatkan keterampilan berpikir kritis siswa di kelas IV Sekolah Dasar. *Jurnal Pendidikan Guru Sekolah Dasar*, 5(3), 21–30.
- Umamah, C., Norhasan, N., & Rofi'ah, J. (2018). Implementasi model problem based learning berbasis literasi sains untuk meningkatkan keterampilan berpikir kritis siswa. *LENSA (Lentera Sains): Jurnal Pendidikan IPA*, 8(2), 67–74. <https://doi.org/10.24929/lensa.v8i2.35>
- Virginia, M., Sabando, G., Rossana, Y., Alcívar, C., Andreina, N., & Pico, S. (2021). *Implementation of ICT in Active Methodologies for the Teaching of Mathematics*. 5(2), 131–139.
- Waite, L. H., Smith, M. A., & McGiness, T. P. (2020). Impact of a problem-based learning elective on performance in non-problem-based learning required courses. *Currents in Pharmacy Teaching and Learning*, 12(12), 1470–1476. <https://doi.org/10.1016/j.cptl.2020.07.015>
- Walfajri, R. U., & Harjono, N. (2019). Hasil belajar tematik muatan Ipa melalui model problem based learning kelas 5 Sd. *Jurnal Basicedu*, 3(1), 16–20.
- Widayanti, Y. (2020). Meningkatkan hasil belajar peserta didik dengan modul pembelajaran berbasis problem based learning (PBL). *Jurnal Pendidikan Ekonomi Undiksha*, 12(1), 166. <https://doi.org/10.23887/jjpe.v12i1.25648>
- Winoto, Y. C., & Prasetyo, T. (2020). Efektivitas model pembelajaran problem based learning dan problem solving terhadap kemampuan berpikir kritis siswa Sekolah Dasar. *Jurnal Basicedu*, 4(2), 228–238. <https://doi.org/10.31004/basicedu.v5i3.892>
- Woa, K. M., Utaya, S., & Susilo, S. (2018). Pengaruh model pembelajaran problem based learning terhadap kemampuan memecahkan masalah Geografi pada Siswa SMA. *Jurnal Pendidikan: Teori, Penelitian Dan Pengembangan*, 3(3), 406–411.
- Wulansari, B., Hanik, N. R., & Nugroho, A. A. (2019). Penerapan model problem based learning (PBL) disertai mind mapping untuk meningkatkan hasil belajar pada siswa kelas X SMA Negeri 1 Tawang Sari. *Journal of Biology Learning*, 1(1), 47–52. <https://doi.org/10.32585/v1i1.250>
- Yuniar, R., Nurhasanah, A., Rahman Hakim, Z., & Asih Vivi Yandari, I. (2022). Peran guru dalam pelaksanaan model Pbl (Problem Based Learning) Sebagai penguatan keterampilan berpikir kritis. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, 7(2), 1134–1150. <https://doi.org/10.23969/jp.v7i2.6408>
- Zhang, Y., Bian, Y., Cao, X., Tang, W., & Li, Q. (2023). Intuition or rationality: Impact of critical thinking dispositions on the cognitive processing of creative information. *Thinking Skills and Creativity*, 48(1037), 101278. <https://doi.org/10.1016/j.tsc.2023.101278>
- Zhou, Z. (2018). An empirical study on the influence of pbl teaching model on college students' critical thinking ability. *English Language Teaching*, 11(4), 15. <https://doi.org/10.5539/elt.v11n4p15>