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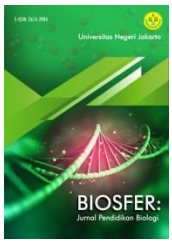

POGIL in biology: improving critical thinking, learning ownership, and cognitive learning outcomes

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ABSTRACT

The improvement of critical thinking, learning ownership, and cognitive learning outcomes has become highly urgent because they are essential foundations in shaping a generation that is adaptive, independent, and competent in supporting the realization of Indonesia Emas 2045. The POGIL offers practical guided inquiry activities to train critical thinking, enhance students' responsibility in learning process, and strengthen conceptual understanding. This research is designed to increase critical thinking, learning ownership, and cognitive learning outcomes by implementing the POGIL. A qualitative approach was employed in this research, utilizing a classroom-based action research method involving students of XI IPA 1 at SMAI Al-Ma'arif Singosari as research subjects. The results indicate that implementing the POGIL positively impacts critical thinking, learning ownership, and cognitive learning outcomes. Data on critical thinking skills show an improvement from moderate to high in the indicators of application, using data to develop critical perspectives, and analysis, meanwhile the increase from low to high occurred in the indicators of evaluating and synthesizing. Additionally, learning ownership improved, marked by the rise from low to moderate across all indicators reflecting their responsibility for the learning process. In the cognitive domain, the average score showed an improvement, with a classical completeness rate of 89.66%. These findings confirm the effectiveness of the POGIL in enhancing essential learning aspects for conceptual mastery and 21st-century skills. POGIL is more effective for concept understanding and problem-solving, thus it needs to be combined with media or technology to optimize its application across various types of learning materials.

INTRODUCTION

Education plays a crucial contribution to Indonesia's development as it influences various aspects of societal life, including social, economic, and technological domains. The vision of Indonesia Emas 2045 heavily relies on the capacity of human capital produced through education, which in turn supports the creation of a sustainable economy and social welfare (Rahmawati, 2025). Therefore, upgrading the quality of education is currently a critical priority to ensure a better life for future generations (Yuan, 2018). One approach to enhancing education quality is by fostering students' critical thinking skills to prepare them for complex future challenges (Zanden et al., 2020).

Critical thinking skills are essential to develop as they help students connect concepts, understand materials, and solve problems in real-life contexts. Critical thinking is a deliberate and structured thinking process that applies high intellectual standards (Greenstein, 2012). These skills include the ability to systematically and scientifically examine events, thereby enabling students to draw logical conclusions (Giri & Paily, 2020). Learners with well-developed critical thinking abilities are generally better at evaluating information, evaluating evidence, and making informed decisions (Plummer et al., 2022). Furthermore, critical thinking motivates students to assume more responsibility for their learning journey, enhancing their sense of control over their education (Gunawardena & Wilson, 2021).

In line with the importance of critical thinking, teaching and learning processes should also consider learning ownership. Learning ownership refers to a condition in which students possess intrinsic motivation, self-confidence, effective learning strategies, and resilience in the face of challenges (Conley & French, 2014). Students with learning ownership tend to independently set learning goals, monitor their progress, and reflect on their learning process (Chung et al., 2021; Suzuki, 2022). This sense of ownership contributes to improved learning outcomes by promoting active engagement in the process of learning (Chamberlin et al., 2023).

Learning outcomes, particularly in the cognitive domain, are key indicators in evaluating the success of education. This domain encompasses thinking skills ranging from remembering to creating (Anderson & Krathwohl, 2001). A good cognitive learning outcomes enable students to understand, apply, and evaluate information acquired through instruction (Ng et al., 2023). Higher-order thinking skills enhance cognitive abilities by integrating facts, analysis, and evaluation, thereby supporting deeper conceptual understanding (Kosasih et al., 2022). Learning ownership also supports students' emotional and psychological development and increases their intrinsic motivation to learn (Ma, 2021).

A needs analysis conducted in July 2024 for Grade XI Science 1 students at SMAI Al-Ma'arif Singosari revealed that students' critical thinking skills, learning ownership, and cognitive learning outcomes still require improvement. The average critical thinking test score was 35.3 (categorized as very low), learning ownership averaged 73.89 (moderate), and the cognitive learning outcome average was 69.38, with more than half of the students not meeting the minimum mastery criteria. This state is confirmed by data from Alkhaldi et al (2022), which explains that classroom instruction still focuses on memorization and lacks opportunities for students to evaluate, analyze, and independently conclude information. Students tend to study due to external pressures rather than internal motivation to understand the material (Chamberlin et al., 2023). Furthermore, the students' cognitive competence and knowledge in Biology remain unsatisfactory since many topics are still difficult to master up to the bachelor level due to their abstract and complex nature (Paidi et al., 2020).

In response to these issues, an innovative learning model is needed to improve students' critical thinking skills, learning ownership, and cognitive learning outcomes. One promising model is the Process Oriented Guided Inquiry Learning (POGIL). This model emphasizes process-based learning, which requires students to actively observe, question, evaluate data and reach conclusions through group work and guided inquiry (Mamombe et al., 2021). POGIL has been proven to enhance critical thinking skills, as it encourages students to work independently and collaboratively to solve problems. Additionally, the model fosters learning ownership through students' active involvement in presenting their discussion results and taking responsibility for their roles within the group (Idul & Caro, 2022). The collaborative and problem-based learning activities in POGIL also contribute to the improvement of students' cognitive learning outcomes (Joshi & Lau, 2023).

This study aims to improve the critical thinking skills, learning ownership, and cognitive learning outcomes of Grade XI Science 1 students at SMAI Al-Ma'arif Singosari through the implementation of the Process Oriented Guided Inquiry Learning model. The research findings are expected to contribute to enhancing education quality through the application of more effective learning strategies. Moreover,

this study is expected to benefit teachers by providing insights into evidence-based and innovative instructional strategies and enrich the scientific discourse on developing learning models that meet students' needs.

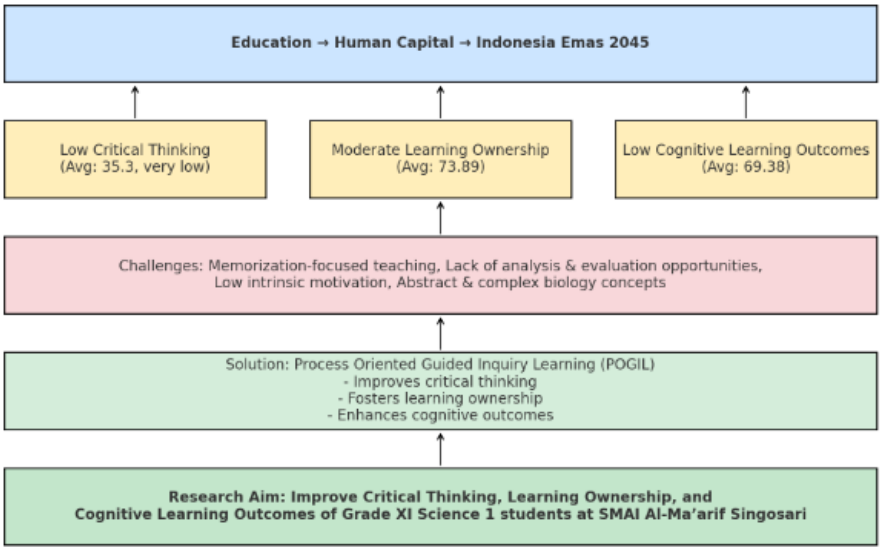

Figure 1. State of the Art

METHODS

Research Design

This study employs a qualitative approach to describe the problems identified in the study and the impact resulting from the implemented actions. The form of research carried out is Classroom Action Research (CAR). The classroom action research was carried out by implementing the Process Oriented Guided Inquiry Learning model to improve the critical thinking skills, learning ownership, and cognitive learning outcomes of grade XI Science 1 students at SMAI Al-Ma'arif Singosari in the topics of the Musculoskeletal System and Circulatory System. The research model design used in this study was adapted from Kemmis et al (2014), which includes the following stages: (1) planning, (2) act, (3) observe, and (4) reflect.

Researcher Attendance

The researcher was directly involved in this study by conducting the learning activities in the classroom to implement the planned actions collaboratively. The researcher also collaborated with the Biology subject teacher and two observers.

Research Location and Duration

This study was conducted at SMAI Al-Ma'arif Singosari, located at Jalan Masjid No. 28, Pangetan, Singosari District, Malang Regency. The study was conducted in the first semester of the 2024/2025 academic year, starting from October to November 2024, with a total of 8 meetings for a minimum of two cycles, consisting of 4 meetings in each cycle.

Research Subject

The research subjects comprised Grade XI IPA 1 at SMAI Al-Ma'arif Singosari in the 2024/2025 academic year, consisting of 29 students in one class, consisting of 8 male students and 21 female students.

Instrument

The research instruments used consisted of a critical thinking skills test, a learning ownership questionnaire, and a cognitive learning outcomes test. The validation results indicated that all three instruments were categorized as highly feasible, with percentages of 97.33%, 100%, and 97.5%, respectively. The validity test showed that the calculated r-values were greater than the r-table values, indicating that the instruments were valid. The reliability test also demonstrated Cronbach's Alpha values of 0.723–0.729, 0.741, and 0.701–0.677, respectively, confirming that the three instruments were

reliable and appropriate to be used as measurement tools in this study. The data gathered in this study consist of descriptions of the improvement of students' critical thinking skills, learning ownership, and cognitive learning outcomes are presented in Table 1.

Table 1.
Data, Instruments, Data Sources, and Data Collection Procedures

Data	Instrumen	Data Source	Data Collection Procedure
Critical Thinking Skills	Test	Students	Administered to students during the preliminary study and at the beginning and end of each cycle
Learning ownership	Questionnaire	Students	Administered to students at the beginning and end of each cycle
Cognitive Learning Outcomes	Test	Students	Administered at the beginning and end of each cycle
Implementation of Process Oriented Guided Inquiry Learning	Learning Implementation Observation Sheet	Model teacher and observers	Observation sheets were given to the observers and Biology teacher

Procedure

This classroom action research comprises stages as illustrated in Figure 2.

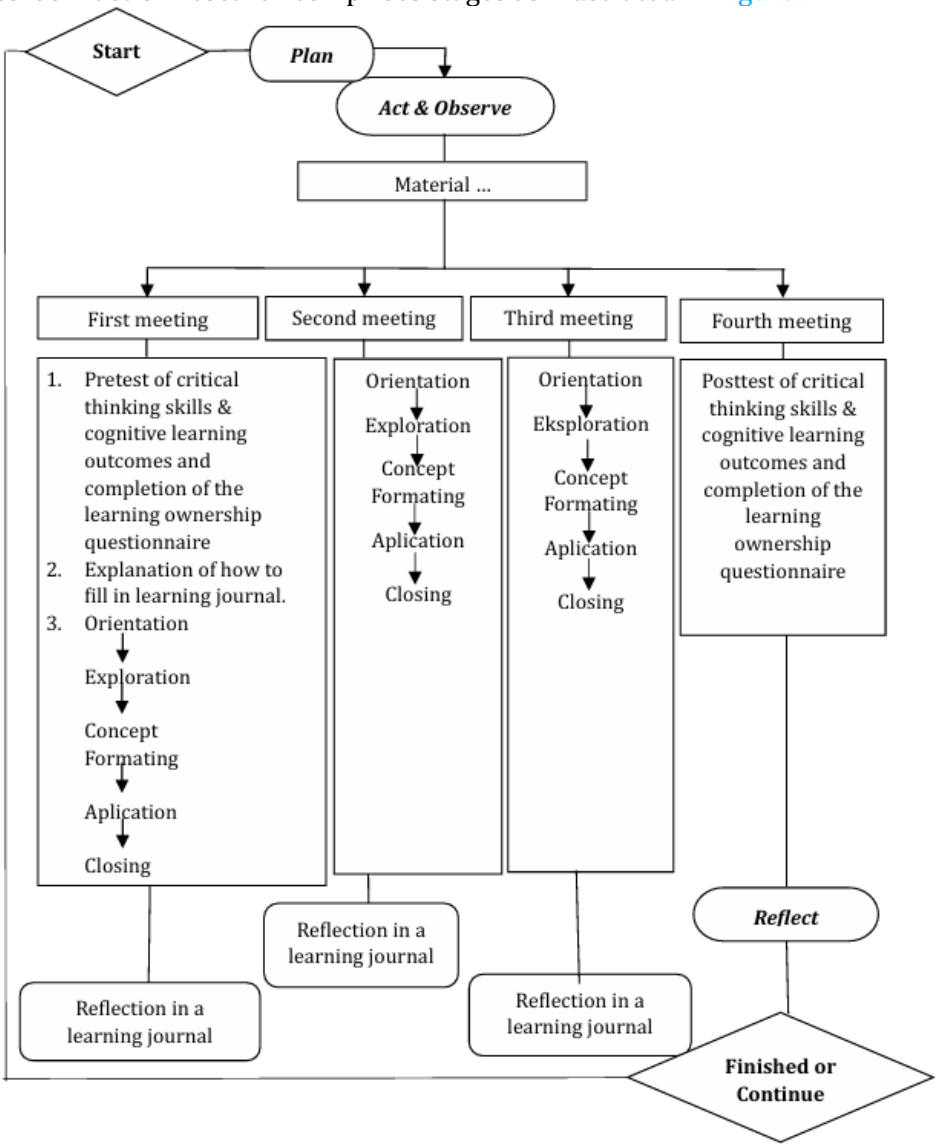

Figure 2. Procedure Research

Data Analysis Techniques

The data was analyzed by processing information regarding the execution of the learning model syntax, N-Gain, classical completeness criteria of 80%, a normality test, and an analysis of learning journals using Word Clouds based on NVivo 12 software. Data validity was ensured through data source triangulation, which involved combining the results of tests, questionnaires, and observations. The N-Gain score criteria are presented in Table 2.

Table 2.
N-Gain Score Criteria

Score Achievement Criteria	Category
N-Gain ≥ 0,7	High
0,3 < N-Gain < 0,7	Medium
N-Gain ≤ 0,3	Low

Sumber: Hake (1999:1)

RESULTS AND DISCUSSION

Improving Critical Thinking through the Process-Oriented Guided Inquiry Learning Model

1. Analysis of Critical Thinking Skills through Student Worksheet and Learning Activities

Students' critical thinking skills are evident through the tasks they have completed as well as the questions raised by the students themselves. This is demonstrated by excerpts of student questions and answers from cycle 1 and cycle 2.

The first indicator, applying, in cycle 1, students were fairly able to apply prior information to new knowledge. However, they were not yet capable of analyzing the factors mentioned in depth about the problems presented. This indicator improved in cycle 2, as evidenced by students' ability to apply prior information to new knowledge very well. Furthermore, students were also able to explain the relationships between causal factors and arguments. This is supported by the following student response excerpts:

> *"The bones prone to osteoporosis are the spine, hips, and wrists because these areas have more porous bone structures, making them more susceptible to decreased bone density. Osteoporosis is caused by a reduction in calcium, estrogen hormones, and collagen, which are important components in maintaining bone density. When the body cannot meet calcium needs and hormonal disturbances occur (such as in breastfeeding mothers in the article), bone density decreases."* (Student Worksheet, Group 1) – Cycle 1.
> *"The main cause of varicose veins is valve failure in the veins, preventing blood from flowing backward. Military schools are demanding, with full physical activity from morning until night. A strong heart is needed; if one has varicose veins, the heart does not work optimally."* (Student Worksheet, Group 1) – Cycle 2.

The second indicator, evaluating, in cycle 1, students were fairly able to evaluate the knowledge they had acquired. The clarified information reinforced the concept through questions posed by the students. This indicator improved in cycle 2, as students had developed correct concepts and then clarified them to ensure accuracy. This is evidenced by the following student questions:

> *"My group found information that the number of leukocytes and erythrocytes differs; there are more red blood cells, right? Yet, white blood cells function as defense. Why is that?"* (Ika) – Cycle
> *"Ma'am, so lymph nodes are part of the lymphatic system, right? They're not a disease?"* (Ika) – Cycle 2.

The indicator involving the use of data to develop critical perspectives, analyze, and synthesize, in cycle 1, students were fairly able to complete assignments related to the movement system. These assignments involved contextual events, such as students developing arguments and analyzing the roles of bones, muscles, and joints based on the provided article. However, in cycle 1, students were not yet

able to provide more in-depth explanations or reasoning. All three indicators improved in cycle 2, where students were able to explain causal factors and the classification of blood groups in the ABO system.

According to Jean Piaget's Cognitive Development Theory, critical thinking skills develop progressively from the concrete stage to the formal operational stage. Students require more time to transition from a basic understanding to a more complex analysis. Cycle 2 provided opportunities for students to further practice these skills, resulting in improved abilities (Susanto et al., 2024).

The analysis of student worksheets and learning activities indicates that students' critical thinking abilities increased from cycle 1 to cycle 2 by implementing the Process Oriented Guided Inquiry Learning model. This model helps transform problems and learning materials into meaningful, interconnected experiences and knowledge (Treagust et al., 2020). Process Oriented Guided Inquiry Learning model encourages students to become active learners throughout the learning process and build understanding. Students are trained to think scientifically and make decisions based on facts and data (Aiman et al., 2020). The enhancement of critical thinking skills is demonstrated by students' capabilities to recognize problems, develop hypotheses, evaluate data, and make logical conclusions.

2. Analysis of Critical Thinking Skills Based on Test Results

Normality testing was conducted before the analysis of N-Gain scores and showed that the significance value was greater than 0.05, indicating that the data were normally distributed. The results of the N-Gain score analysis are presented in Figure 3.

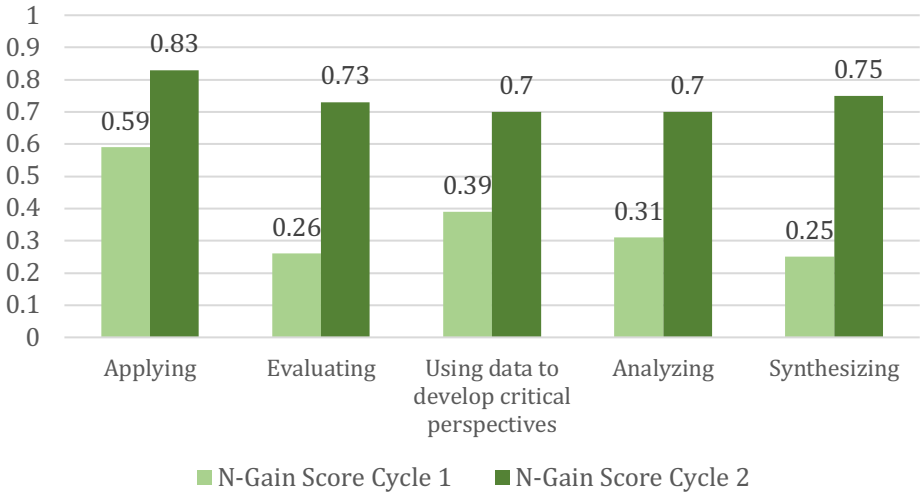

Figure 3. Improvement of Critical Thinking Skills in Cycles 1 and 2 Based on N-Gain Scores

The results of the N-Gain score analysis show that from cycle 1 to cycle 2, there was a development in critical thinking skills. The indicators of applying, using data to develop critical perspectives, and analyzing increased from medium to high. The indicators of evaluating and synthesizing improved from low to high. In cycle 1, students were still adapting to this model, so skills such as applying and using data developed more quickly, as these activities were more concrete and directly implemented in assignments. Over time, in cycle 2, an enhanced comprehension of the inquiry process allowed individuals to develop higher-order analytical skills such as evaluating and synthesizing. Overall, critical thinking skills were at a medium level in cycle 1 and improved to a high level in cycle 2.

Critical thinking skills are well facilitated by the Process Oriented Guided Inquiry Learning model through exploration, concept formation, and application activities. These skills are closely related to the ability to utilize new concepts for solving issues. This ability helps students identify and understand problems by evaluating relevant information, analyzing problem aspects, and assessing various solutions (Shanta & Wells, 2022). Critical thinking also encourages creativity in finding innovative solutions, supports more accurate decision-making, and facilitates reflection on outcomes and processes. As a result, students can learn from experience and continuously improve their skills (Rivas et al., 2022).

Learning activities using the Process Oriented Guided Inquiry Learning model overall facilitate the development of students' critical thinking skills. This learning model involves data collection activities, including identifying, gathering, and processing relevant information to generate logical

conclusions. Data collection includes stages such as classification, assessment, drawing conclusions, and applying strategies and tactics, all of which promote the improvement of critical thinking skills particularly in the indicator of using data to develop critical perspectives (Sutiani et al., 2021). Data collection activities also involve analyzing and synthesizing information. Analyzing information plays a role in organizing mental processes to support decision-making. It helps students discover new information, find appropriate solutions, and better understand the material (Kavousi et al., 2020). Meanwhile, synthesizing information allows individuals to combine various information sources to produce new knowledge and enrich insights (Reynders et al., 2020).

Critical thinking skills are also facilitated through concept formation activities, as students can better understand the concepts. This stage involves the ability to evaluate learned concepts, supporting a more comprehensive understanding (Chen & Hwang, 2020). Presenting discovery results helps students clarify their understanding, assess relevant information, and draw logical conclusions through reflection (Ananda et al., 2023). Furthermore, guided questions during presentations assist students in better understanding the topic. Relevant questions support students in thinking more deeply and critically about the material being studied (Shanmugavelu et al., 2020).

The Process Oriented Guided Inquiry Learning model encourages students to connect new information with prior knowledge. This ability helps students apply and understand the material. In addition, it enables students to see the interrelationships between concepts, ultimately supporting the development of deeper and more critical thinking on a topic (Fateh et al., 2024). Connecting new information with prior knowledge is an essential element in improving critical thinking skills. This process helps individuals analyze and evaluate information more effectively, identify patterns, make generalizations, and find alternative solutions through in-depth analysis (Goodsett, 2020).

Improving Learning Ownership through the Process-Oriented Guided Inquiry Learning Model

1. Results of the Learning Journal Analysis

Learning journals encourage students to evaluate their learning and how the learning process has occurred. This helps students better understand their learning processes, increase their awareness of progress, and foster responsibility for their learning. The positive learning experiences gained include ownership, focus on the whole course, regular reading, awareness of learning, self-confidence, reflectivity, and engagement with the material (Park, 2003).

In this study, learning journals were used as a medium for students to evaluate their learning journey, understand their personal development, and identify challenges encountered during the learning process. The following are excerpts from students' learning journals, serving as evidence of the development of students' learning ownership:

"Today, I learned about the human movement system. I felt interested because I discovered many new things, such as how muscles collaborate with bones to move. At first, I had difficulty understanding the function of each type of joint, but I tried to search for additional images on the internet to clarify. I wanted to be able to explain this material well, so I made small notes. Although I'm still a bit confused, I believe that if I keep learning, I'll understand it more deeply." (Cherell) – Cycle 1

"Today, I studied the human circulatory system. I'm becoming more confident in learning because I can begin to connect this material to everyday life, such as the importance of maintaining heart and blood vessel health. I created a concept map about blood flow from the heart to the rest of the body to better understand the process. When I encountered difficult parts, such as the mechanism of heart valves, I asked a friend and wrote down the explanation. I also set a goal to learn more about diseases related to this system because I want to take better care of my health. Learning this time felt more structured, and I'm feeling more enthusiastic." (Cherell) – Cycle 2

These journal excerpts demonstrate improved motivation, more specific goal orientation, increased self-confidence, better monitoring ability, and more directed persistence in learning. This reflects the role of consistent self-reflection in helping students understand their learning process, evaluate their strengths and weaknesses, and develop more effective and sustainable learning strategies. This progress indicates that student-centered learning through Process Oriented Guided Inquiry Learning successfully promotes student autonomy and learning ownership. The results of the qualitative analysis using NVivo 12 in cycle 1 were then visualized using the word cloud feature as shown in Figure 4.

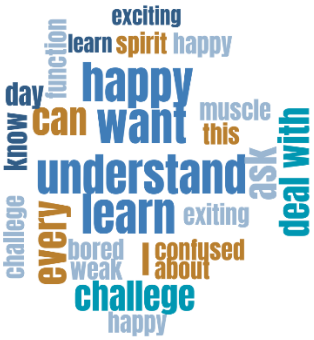

Figure 4. Word Cloud of Learning Journal Cycle 1

Furthermore, the results of the qualitative analysis using NVivo 12 in cycle 2 were also visualized using the word cloud feature in Figure 5.

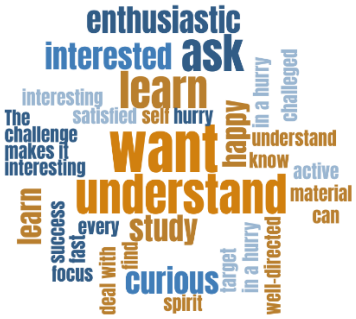

Figure 5. Word Cloud of Learning Journal Cycle 2

The analysis of word frequency results using NVivo 12, visualized through a word cloud, compares the frequency of words appearing in the texts from cycle 1 and cycle 2. Dominant words in the cycle 1 word cloud include *"understand"*, *"learn"*, and *"want"*. This indicates that students had goals, direction, and control over their learning, demonstrating a desire to learn specific material at the beginning of the lesson and the ability to achieve their initial objectives by the end. Words like *"happy"*, *"enthusiastic"*, and *"exciting"* suggest that students enjoyed the process and were motivated from within. The word *"ask"* also appears, indicating active student participation in group and class discussions. Additionally, the phrase *"able to face challenges"* signifies that students were capable of handling the responsibilities or assignments given. However, the cycle 1 word cloud also includes words such as *"bored"*, *"tired"*, and *"confused"*, implying that some students had not yet fully enjoyed the learning process, possibly due to the lack of intrinsic motivation. In cycle 2, dominant words included *"want"*, *"study"*, and *"understand"*, reflecting students' ability to set learning goals and direction. The word *"ask"* reappears, though in the fourth position. Nevertheless, the frequency of students asking questions was higher in cycle 1, suggesting that students had become more independent in cycle 2. Words like *"interested"*, *"curious"*, *"happy"*, and *"enthusiastic"* indicate that students enjoyed the learning process with a sense of curiosity. The word *"focused"* reflects the persistence of students in reaching their individual goals.

The review of students' learning journals indicates an increase in their learning ownership. Students developed their strategies for understanding the material, showing a sense of ownership and accountability for their learning. Developing personal learning strategies helps students become more independent, motivated, and confident during the learning process (El-Adl & Alkharusi, 2020). Students also tended to ask questions when confused, understand what they were learning, and face challenges effectively. The act of questioning is a form of engagement, showing that students actively participate in academic activities and have confidence (Aflalo, 2021). Focusing on learning through discussion activities can also enhance students' sense of ownership in the classroom, as it helps them feel more engaged and actively involved in achieving learning goals (Cao & Yu, 2023).

The implementation of the Process Oriented Guided Inquiry Learning model has proven to be effective in developing students' learning ownership, as evidenced by improvements in all related indicators. Group interaction, exploration, and reflection helped students develop independent learning strategies, better understand the material, and take responsibility for their learning process. Active

engagement in each stage of learning transformed students from mere receivers of information into learners who are aware of their learning goals, methods, and outcomes. This created a more meaningful and self-directed learning experience. These results indicate that the Process Oriented Guided Inquiry Learning model is effective in building learning ownership, making students more independent, persistent, and metacognitively aware in facing academic challenges.

2. Results of the Learning Ownership Questionnaire

Normality testing was conducted before the analysis of N-Gain scores and showed a significance score higher than 0.05, implying the data adhered to a normal distribution. The results of the N-Gain score analysis are presented in Figure 6.

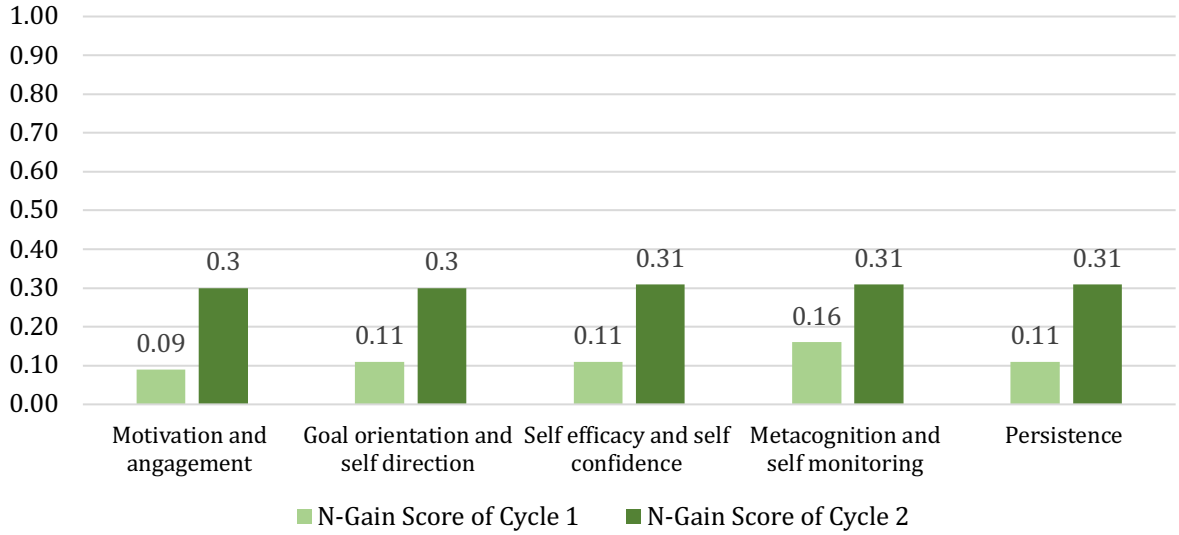

Figure 6. Improvement of Learning Ownership in Cycles 1 and 2 Based on N-Gain Scores

The implementation of the Process Oriented Guided Inquiry Learning model in both cycle 1 and cycle 2 was able to enhance students' learning ownership. Group interactions within the Process Oriented Guided Inquiry Learning model allowed for discussions, mutual assistance, and a sense of support, which increased individual engagement. Active learning involving exploration, discussion, and problem-solving made students more interested and motivated due to their direct involvement. In addition, the teacher, acting as a facilitator, guided and directed students in exploration activities and discovery of new information, which fostered a sense of being appreciated and thus enhanced learning motivation (Yang et al., 2020). This learning model highlights the significance of metacognition by encouraging students to reflect on their progress and assess their performance, thereby making them aware of their responsibility for learning. Process Oriented Guided Inquiry Learning model also assigns responsibility to each individual to understand the material and contribute to the team through assigned roles such as manager, presenter, recorder, and reflector (Hanson, 2006).

The implementation of the Process Oriented Guided Inquiry Learning model allows each team member to have a specific role to ensure effective learning. The manager is responsible for keeping the team focused, distributing tasks, resolving conflicts, and ensuring that all members participate and understand the material. The presenter is in charge of delivering the team's discussion results to the class, explaining the conclusions reached, and representing the majority view of the group. The recorder notes down instructions, documents teamwork, and prepares a written report based on the discussions. Meanwhile, the reflector identifies problem-solving strategies, notes what the team has done well and areas for improvement, and then compiles a reflection report on the team's learning process (Hanson, 2006).

The results of the Process Oriented Guided Inquiry Learning model implementation in cycle 1 showed a low level of improvement. This was due to students still adjusting to the applied learning model. Previously, learning activities were mainly teacher-directed, with conceptual questions such as asking about the organic and inorganic components of cells. Furthermore, students' initial learning ownership was already fairly good, as Class XI IPA 1 was a top-performing class. The Process Oriented Guided Inquiry Learning model requires each student to understand their role within the group.

Moreover, students must become accustomed to guided inquiry activities to build understanding through exploration, concept formation, and application. They also need to develop metacognitive skills, such as reflection, to understand progress and address weaknesses (Hanson, 2006).

A moderate improvement was observed in cycle 2 due to the continued implementation of the Process Oriented Guided Inquiry Learning model. Students began to adapt to the learning pattern, understood the flow of activities, and were able to follow instructions more effectively. A high improvement was not observed, as students had diverse initial abilities that influenced their learning motivation. This was evident from the pretest and posttest scores in cycles 1 and 2. In the cycle 1 pretest, 11 students were categorized as "low." In the cycle 1 posttest, only 3 students remained in the "low" category, as others had moved up to "moderate." In cycle 2, the number of students in the "low" and "medium" categories in the pretest was 3 and 13, respectively. By the posttest in cycle 2, all students had improved and were categorized as "good."

Learning ownership was well facilitated by the Process Oriented Guided Inquiry Learning model during the orientation, exploration, and closing phases. Motivating the orientation phase aimed to spark students' interest in learning. Curiosity and interest in the material prompted students to be actively involved in the learning process. This interest and motivation led students to be more active and persistent when facing challenges during learning (Yin et al., 2021). The presence of stimulating learning activities helped create a dynamic classroom environment, thus motivating students further and encouraging active participation. The effect was that students became better at determining their learning steps, allowing their goal orientation and self-direction to develop (Hellín et al., 2023).

The Process Oriented Guided Inquiry Learning model provides opportunities for students to share their thoughts and ideas, which boosts their confidence in their abilities, or self-efficacy and self-confidence. Self-confidence helps individuals have an optimistic view of themselves and the situations, allowing them to achieve goals and perform tasks effectively (Pranitasari et al., 2024). Group collaboration activities also enabled discussions and joint problem-solving, encouraged persistence in finding solutions, and fostered the development of new ideas. Thus, the problem-solving process strengthened students' persistence in facing academic challenges (Carbonneau et al., 2020).

The Process Oriented Guided Inquiry Learning model facilitates students in reflecting on their learning activities. Reflection activities help students reflect on their capabilities and areas for improvement and prepare action plans for progress. Reflection and self-assessment activities also allow students to evaluate and continuously reflect on their work. This process allows students to assess their performance, encouraging them to become more responsible and independent learners, thereby developing their metacognition and self-monitoring skills (Arefian, 2022).

Improving Cognitive Learning Outcomes through the Process-Oriented Guided Inquiry Learning Model

Normality testing was conducted before the analysis of N-Gain scores and showed a significance score higher than 0.05, implying the data adhered to a normal distribution. The cognitive learning outcome data are shown in Table 3.

Table 3.
Cognitive Learning Outcomes of Class IPA 1 Students at SMAI Al-Ma'Arif Singosari

Aspect	Cycle 1 (Movement System)		Cycle 2 (Circulatory System)	
	Pretest	Posttest	Pretest	Posttest
Average	46.03	78.28	65	90
N-gain Scores	0.60 (medium)		0.71 (high)	
Individual Mastery	0 students	24 students	9 students	26 students
Individual Mastery	0%	82.76%	31.03%	89.66%

Cognitive test results showed a notable improvement in students' learning outcomes. The increase from pre-test to post-test in cycle 1 was classified as moderate, while the improvement in Cycle 2 was considered high. Based on the analysis, cognitive indicators showed the most significant improvement at the C4 level, which involves analyzing. The Process-Oriented Guided Inquiry Learning model guided students through a structured process, starting from identifying problems to evaluating solutions. This process helped students enhance their analytical skills through critical thinking

(Karaoglan & Fatma, 2022). The model also encouraged students to ask questions, explore, and independently construct concepts. As a result, students learned to analyze information and data collected during learning, thereby strengthening their understanding and analytical thinking skills (Idul & Caro, 2022).

The Process Oriented Guided Inquiry Learning model demonstrated a direct correlation with the improvement of cognitive learning outcomes. It promoted active student participation during the learning process, which enhanced their comprehension of the subject matter (Zemene et al., 2025). This model supported students in exploring concepts, analyzing, and interpreting scientific information more deeply while also developing problem-solving skills. Through this process, students' enthusiasm, motivation, and active engagement were fostered, contributing significantly to their cognitive learning gains (Acosta & Ramirez, 2022).

Process Oriented Guided Inquiry Learning model engaged students in a series of structured scientific activities, including orientation, exploration, concept formation, application, and closure. These activities were designed to encourage systematic, critical, and analytical thinking in solving problems and independently constructing concepts. Students were given opportunities to respond to questions through scientific processes, such as formulating hypotheses, conducting observations, and analyzing observational data (Mamombe et al., 2022). The model played a key role in improving students' critical and analytical thinking skills and scientific reasoning skills. The structured learning experiences encouraged deep, organized learning that made a significant contribution to the improvement of cognitive learning outcomes (Shu & Gu, 2023).

The Process Oriented Guided Inquiry Learning model is designed to stimulate active student engagement in acquiring knowledge, conceptual understanding, and reasoning ability. In its implementation, the teacher serves as a mediator and facilitator, while students participate in solo or group-based activities to discover new concepts through discussion and experimentation. Overall, the application of Process Oriented Guided Inquiry Learning model increases students' cognitive learning outcomes by promoting activeness, independence, and critical thinking skills throughout the learning process (Sari et al., 2020).

The research findings indicate that the process-oriented nature of Process Oriented Guided Inquiry Learning model contributes meaningfully to the development of students' cognitive learning outcomes. The greatest improvement occurred at the C4 cognitive level (analyzing), as the model's structured learning stages encouraged critical thinking, exploration, and problem-solving. The scientific activities embedded in this model reinforced conceptual understanding, analytical skills, and student engagement. The teacher serving as a facilitator also supported students in becoming more independent, active, and capable of interpreting scientific information at a deeper level.

CONCLUSION

This study found that applying the Process Oriented Guided Inquiry Learning (POGIL) model successfully improved students' critical thinking, learning ownership, and cognitive learning outcomes. Critical thinking skills increased, with application, data use, and analysis moving from moderate to high, while evaluation and synthesis rose from low to high. Learning ownership also improved as students became more responsible, confident, and persistent, though it was still in the moderate category. Cognitive outcomes showed a strong increase, with an average score reaching 89.66% completeness, especially in analytical skills (C4). Overall, POGIL proved effective in engaging students, supporting problem-solving, and strengthening understanding, and it can be further optimized by combining it with media or technology.

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REFERENCES

Acosta, G. E. & Ramirez, A. A. (2022). Scaffolding Matters? Investigating Its Role in Motivation, Engagement and Learning Achievements in Higher Education. *Sustainability (Switzerland)*, *14*(20). https://doi.org/10.3390/su142013419

Aflalo, E. (2021). Students Generating Questions as a Way of Learning. *Active Learning in Higher Education*, *22*(1), 63–75. https://doi.org/10.1177/1469787418769120
Aiman, U., Hasyda, S. & Uslan. (2020). The Influence of Process Oriented Guided Inquiry Learning (POGIL) Model Assisted by Realia Media to Improve Scientific Literacy and Critical Thinking Skill of Primary School Students. *European Journal of Educational Research*, *9*(4), 1635–1647. https://doi.org/10.12973/EU-JER.9.4.1635
Alkhaldi, A. A., Ozdemir, E. A. & Alhasan, R. F. (2022). ESP Creative Writing from Engineering Students' Perspective: A Case Study. *International Journal of English Language and Literature Studies*, *11*(3), 136–146. https://doi.org/10.55493/5019.v11i3.4613
Ananda, L. R., Rahmawati, Y. & Khairi, F. (2023). Critical Thinking Skills of Chemistry Students by Integrating Design Thinking with STEAM-PJBL. *Journal of Technology and Science Education*, *13*(1), 352–367. https://doi.org/10.3926/jotse.1938
Anderson, L. W. & Krathwohl, D. R. (2001). *Kerangka Landasan untuk Pembelajaran, Pengajaran dan Asesmen (Revisi Taksonomi Pendidikan Bloom)*. Pustaka Pelajar.
Arefian, M. H. (2022). Perceptions of Self-assessment Literacy and Self-directed Reflection during Online Learning for Iranian EFL Student Teachers. *Reflective Practice*, *23*(6), 623–634. https://doi.org/10.1080/14623943.2022.2096584
Cao, W. & Yu, Z. (2023). Exploring Learning Outcomes, Communication, Anxiety, and Motivation in Learning Communities: A Systematic Review. In *Humanities and Social Sciences Communications* (Vol. 10, Issue 1). Springer Nature. https://doi.org/10.1057/s41599-023-02325-2
Carbonneau, K. J., Wong, R. M. & Borysenko, N. (2020). The Influence of Perceptually Rich Manipulatives and collaboration on Mathematical Problem-solving and Perseverance. *Contemporary Educational Psychology*, *61*. https://doi.org/10.1016/j.cedpsych.2020.101846
Chamberlin, K., Yasué, M. & Chiang, I. C. A. (2023). The impact of grades on student motivation. *Active Learning in Higher Education*, *24*(2), 109–124. https://doi.org/10.1177/1469787418819728
Chen, M. R. A. & Hwang, G. J. (2020). Effects of a Concept Mapping-Based Flipped Learning Approach on EFL Students' English Speaking Performance, Critical Thinking Awareness and Speaking Anxiety. *British Journal of Educational Technology*, *51*(3), 817–834. https://doi.org/10.1111/bjet.12887
Chung, H. Q., Chen, V. & Olson, C. B. (2021). The Impact of Self-assessment, Planning and Goal Setting, and Reflection Before and After Revision on Student Self-efficacy and Writing Performance. *Reading and Writing*, *34*(7), 1885–1913. https://doi.org/10.1007/s11145-021-10186-x
Conley, D. T. & French, E. M. (2014). Student ownership of learning as a key component of college readiness. *American Behavioral Scientist*, *58*(8), 1018–1034. https://doi.org/10.1177/0002764213515232
El-Adl, A. & Alkharusi, H. (2020). Relationships Between Self-regulated Learning Strategies, Learning Motivation and Mathematics Achievement. *Cypriot Journal of Educational Sciences*, *15*(1), 104–111. https://doi.org/10.18844/cjes.v15i1.4461
Fateh, S., Ayangbola, O. T., Reid, J. W., Zakher, S. W., Kirbulut Gunes, Z. D., Phelps, A. J., Malone, A. & Rushton, G. T. (2024). Small Group Conversations in a POGIL-Based Class: How English Learners Engage in a Joint Knowledge Construction Process to Reach a Shared Understanding. *Journal of Chemical Education*, *101*(3), 741–752. https://doi.org/10.1021/acs.jchemed.2c00624
Giri, V. & Paily, M. U. (2020). Effect of Scientific Argumentation on the Development of Critical Thinking. *Science and Education*, *29*(3), 673–690. https://doi.org/10.1007/s11191-020-00120-y
Goodsett, M. (2020). Best Practices for Teaching and Assessing Critical Thinking in Information Literacy Online Learning Objects. *Journal of Academic Librarianship*, *46*(5). https://doi.org/10.1016/j.acalib.2020.102163
Greenstein. (2012). *ASSESSING 21st Century SKILLS: A Guide to Evaluating Mastery and Authentic Learning*. A SAGE Company.
Gunawardena, M. & Wilson, K. (2021). Scaffolding Students' Critical Thinking: A Process Not an End Game. *Thinking Skills and Creativity*, *41*. https://doi.org/10.1016/j.tsc.2021.100848
Hanson, D. M. . (2006). *Instructor's Guide to Process-Oriented Guided-Inquiry Learning*. Pacific Crest.
Hellín, C. J., Calles-Esteban, F., Valledor, A., Gómez, J., Otón-Tortosa, S. & Tayebi, A. (2023). Enhancing Student Motivation and Engagement through a Gamified Learning Environment. *Sustainability (Switzerland)*, *15*(19). https://doi.org/10.3390/su151914119
Idul, J. J. A. & Caro, V. B. (2022). Does Process-oriented Guided Inquiry Learning (POGIL) Improve

Students' Science Academic Performance and Process Skills? *International Journal of Science Education*, *44*(12), 1994–2014. https://doi.org/10.1080/09500693.2022.2108553
Joshi, N. & Lau, S. K. (2023). Effects of Process-oriented Guided Inquiry Learning on Approaches to Learning, Long-term Performance, and Online Learning Outcomes. *Interactive Learning Environments*, *31*(5), 3112–3127. https://doi.org/10.1080/10494820.2021.1919718
Karaoglan, Y. & Fatma, G. (2022). Utilizing Learning Analytics to Support Students' Academic Self-efficacy and Problem-Solving Skills. *Asia-Pacific Education Researcher*, *31*(2), 175–191. https://doi.org/10.1007/s40299-020-00548-4
Kavousi, S., Miller, P. A. & Alexander, P. A. (2020). Modeling Metacognition in Design Thinking and Design Making. *International Journal of Technology and Design Education*, *30*(4), 709–735. https://doi.org/10.1007/s10798-019-09521-9
Kosasih, A., Supriyadi, T. & Rahminawati, N. (2022). Hasan Aydin Higher-Order Thinking Skills in Primary School. *Journal of Ethnic and Cultural Studies*, *9*(1), 56–76. https://doi.org/10.2307/48710289
Ma, Q. (2021). The Role of Teacher Autonomy Support on Students' Academic Engagement and Resilience. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.778581
Mamombe, C., Mathabathe, K. C. & Gaigher, E. (2021). Teachers' and Learners' Perceptions of Stoichiometry using POGIL: A Case Study in South Africa. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(9), 1–11. https://doi.org/10.29333/ejmste/11140
Mamombe, C., Mathabathe, K. C. & Gaigher, E. (2022). From the Familiar to the Abstract: Exploring Grade 11 Learners' Development in Stoichiometry Problem Solving Competency with Exposure to POGIL. *African Journal of Research in Mathematics, Science and Technology Education*, *26*(2), 166–180. https://doi.org/10.1080/18117295.2022.2115652
Ng, D. T. K., Leung, J. K. L., Su, J., Ng, R. C. W. & Chu, S. K. W. (2023). Teachers' AI Digital Competencies and Twenty-first Century Skills in the Post-pandemic World. *Educational Technology Research and Development*, *71*(1), 137–161. https://doi.org/10.1007/s11423-023-10203-6
Paidi, P., Mercuriani, I. S. & Subali, B. (2020). Students' Competence in Cognitive Process and Knowledge in Biology Based on Curriculum Used in Indonesia. *International Journal of Instruction*, *13*(3), 491–510. https://doi.org/10.29333/iji.2020.13334a
Park, C. (2003). Engaging Students in the Learning Process: The Learning Journal. *Journal of Geography in Higher Education*, *27*(2), 183–199. https://doi.org/10.1080/03098260305675
Plummer, K. J., Kebritchi, M., Leary, H. M. & Halverson, D. M. (2022). Enhancing Critical Thinking Skills through Decision-Based Learning. *Innovative Higher Education*, *47*(4), 711–734. https://doi.org/10.1007/s10755-022-09595-9
Pranitasari, D., Anhar, M., Warcito, Said, M., Harini, S. & Endri, E. (2024). Optimism and Entrepreneurial Self-efficacy in Indonesia MSMEs. *Journal of Infrastructure, Policy and Development*, *8*(10). https://doi.org/10.24294/jipd.v8i10.6238
Rahmawati, I. (2025). The golden generation 2045 and early childhood education: Between idealism and economic reality. In *Policy Futures in Education*. SAGE Publications Inc. https://doi.org/10.1177/14782103251320536
Reynders, G., Lantz, J., Ruder, S. M., Stanford, C. L. & Cole, R. S. (2020). Rubrics to Assess Critical Thinking and Information Processing in Undergraduate STEM Courses. *International Journal of STEM Education*, *7*(1). https://doi.org/10.1186/s40594-020-00208-5
Rivas, S. F., Saiz, C. & Ossa, C. (2022). Metacognitive Strategies and Development of Critical Thinking in Higher Education. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.913219
Sari, D. Y., Iis, I. W. & Kusumawardani, R. (2020). The Influence of POGIL Model with Experiment Method on Student Cognitive Ability of Solubility and Solubility Produc. *Bivalen: Chemical Studies Journal*, *3*(2). https://doi.org/10.30872/bcsj.v3i2.445
Shanmugavelu, G., Ariffin, K., Vadivelu, M., Mahayudin, Z. & R K Sundaram, M. A. (2020). Questioning Techniques and Teachers' Role in the Classroom. *Shanlax International Journal of Education*, *8*(4), 45–49. https://doi.org/10.34293/education.v8i4.3260
Shanta, S. & Wells, J. G. (2022). T/E Design Based Learning: Assessing Student Critical Thinking and Problem Solving Abilities. *International Journal of Technology and Design Education*, *32*(1), 267–285. https://doi.org/10.1007/s10798-020-09608-8
Shu, X. & Gu, X. (2023). An Empirical Study of A Smart Education Model Enabled by the Edu-Metaverse

to Enhance Better Learning Outcomes for Students. *Systems*, *11*(2). https://doi.org/10.3390/systems11020075

Susanto, A. H., Wulandari, M. D. & Darsinah. (2024). Optimalisasi Pembelajaran Anak Usia Sekolah Dasar melalui Pemahaman Teori Perkembangan Kognitif Jean Piaget. *Jurnal Ilmiah Pendidikan Dasar*, *9*(4), 689–706. https://doi.org/10.23969/jp.v9i4.17102

Sutiani, A., Situmorang, M. & Silalahi, A. (2021). Implementation of an Inquiry Learning Model with Science Literacy to Improve Student Critical Thinking Skills. In *International Journal of Instruction* (Vol. 14, Issue 2). https://www.e-iji.net

Suzuki, R. (2022). *The Learning Ownership*.

Treagust, D. F., Qureshi, S. S., Vishnumolakala, V. R., Ojeil, J., Mocerino, M. & Southam, D. C. (2020). Process-Oriented Guided Inquiry Learning (POGIL) as a Culturally Relevant Pedagogy (CRP) in Qatar: a Perspective from Grade 10 Chemistry Classes. *Research in Science Education*, *50*(3), 813–831. https://doi.org/10.1007/s11165-018-9712-0

Yang, Y., Long, Y., Sun, D., Van Aalst, J. & Cheng, S. (2020). Fostering Students' Creativity Via Educational Robotics: An Investigation of Teachers' Pedagogical Practices Based on Teacher Interviews. *British Journal of Educational Technology*, *51*(5), 1826–1842. https://doi.org/10.1111/bjet.12985

Yin, J., Goh, T. T., Yang, B. & Xiaobin, Y. (2021). Conversation Technology With Micro-Learning: The Impact of Chatbot-Based Learning on Students' Learning Motivation and Performance. *Journal of Educational Computing Research*, *59*(1), 154–177. https://doi.org/10.1177/0735633120952067

Yuan, Z. (2018). Dual Priority Agenda: China's Model for Modernizing Education. *ECNU Review of Education*, *1*(1), 5–33. https://doi.org/10.30926/ecnuroe2018010102

Zanden, P. J. A. C., Denessen, E., Cillessen, A. H. N. & Meijer, P. C. (2020). Fostering Critical Thinking Skills in Secondary Education to Prepare Students for University: Teacher Perceptions and Practices. *Research in Post-Compulsory Education*, *25*(4), 394–419. https://doi.org/10.1080/13596748.2020.1846313

Zemene, A. B., Eticha, A. T. & Bekana, D. (2025). Process oriented guided inquiry learning: A possible solution to improve high school students' conceptual understanding of electrochemistry and attitude. *Chemistry Teacher International*. https://doi.org/10.1515/cti-2025-0035