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Beyond Discovery Learning: The Impact of the Mordiscvein Model on Students' Critical Thinking Skills in Biology

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ABSTRACT

Critical thinking skills are essential competencies for students in the 21st century; however, conventional instructional models such as discovery learning often fail to optimally foster students' engagement in higher-order thinking processes. This study examined the effect of the Mordiscvein learning model on senior high school students' critical thinking skills in biology compared with the discovery learning model. A quasi-experimental design with a non-equivalent control group was employed involving 72 tenth-grade students (36 experimental, 36 control) at a public senior high school in Bandar Lampung, Indonesia. The intervention was conducted over four weeks (eight 90-minute sessions). Data were collected using a 10-item essay-based critical thinking test covering analysis, inference, and evaluation indicators, with acceptable reliability (Cronbach's α = 0.82). The results indicated that students taught using the Mordiscvein model achieved significantly higher posttest scores than those in the discovery learning group. Improvements were observed across all critical thinking indicators, suggesting that structured inquiry stages problem orientation, collaborative inquiry, guided experimentation, data interpretation, and reflective discussion—contribute to deeper cognitive engagement. These findings indicate that integrating systematic scaffolding into constructivist learning environments can more effectively support the development of critical thinking in biology education.

INTRODUCTION

The development of critical thinking skills has become a fundamental goal of education in the 21st century, particularly in secondary education, where students are expected to transition from basic knowledge acquisition to higher-order cognitive engagement (Amanulloh et al., 2024; Handoko et al., 2024; Irwandani et al., 2025; Miterianifa et al., 2021). Critical thinking enables learners to analyze information critically, evaluate evidence, formulate logical arguments, and make reasoned decisions when faced with complex problems (Ennis, 1996; Hidayah et al., 2017; Putri et al., 2024). These skills are essential not only for academic success but also for lifelong learning and adaptability in a rapidly changing global society characterized by information overload, technological advancement, and increasing uncertainty (Aslamiah et al., 2021; Asri et al., 2023).

Despite the acknowledged importance of critical thinking skills in 21st-century education, both the current preliminary study and prior research indicate that students' critical thinking remains low in practice. The preliminary test conducted in this study showed that a large proportion of students performed poorly on critical thinking tasks, particularly in analysis, inference, and evaluation, with most scores falling below the minimum competency expectations.

These findings align with several studies in the Indonesian context demonstrating consistently low critical thinking outcomes: for example, research on scientific literacy tasks found that students' critical thinking in assessment, inference, and strategy was below 20%, indicating that most learners struggle to engage in higher-order reasoning required for scientific problem solving (Pamungkas et al., 2018). Another descriptive study reported that only a minority of students scored above 50% on critical thinking assessments in science subjects, highlighting pervasive challenges in fostering analytical and evaluative skills (Hayati & Setiawan, 2022). These converging lines of evidence suggest that, despite curricular reforms and learner-centered pedagogies, existing instructional approaches may not adequately develop the structured reasoning processes essential for critical thinking.

In response to these demands, educational reforms across various countries emphasize student-centered learning approaches that actively involve learners in constructing knowledge (Darling-Hammond et al., 2024; UNESCO, 2018). Instructional practices are no longer expected to focus solely on content delivery but rather on fostering cognitive processes that support reasoning, reflection, and problem-solving (Bhuttah et al., 2024; Daulika et al., 2025; Kusuma & Fauzi, 2025). Consequently, the cultivation of critical thinking skills has become a central indicator of instructional effectiveness, particularly within science and general education contexts at the secondary school level.

Constructivist learning theories provide a strong theoretical foundation for the development of critical thinking skills (Amrullah et al., 2025; Hussain et al., 2025; Subarjo et al., 2023). These theories posit that knowledge is actively constructed through interaction with learning environments rather than passively received from teachers. One instructional approach grounded in constructivism is discovery learning, which encourages students to explore concepts, identify patterns, and derive principles independently through guided activities. discovery learning has been widely implemented in secondary education due to its perceived ability to promote autonomy, curiosity, and conceptual understanding (Hidayatul et al., 2020; Putu et al., 2026; Ramadhanti et al., 2023).

Despite its widespread adoption, empirical studies indicate that discovery learning does not always lead to optimal development of critical thinking skills. In many classroom implementations, students experience difficulties in formulating meaningful problems, analyzing arguments systematically, and drawing valid conclusions from learning experiences (Samosir et al., 2024; Srinawati & Alwi, 2020; Umbara et al., 2025). Without adequate cognitive scaffolding, discovery learning may lead students to focus on procedural task completion rather than deep analytical reasoning.

Recent empirical studies show that minimally guided discovery is significantly less effective at developing higher-order and critical thinking skills than guided or scaffolded approaches, particularly for learners with limited prior knowledge or metacognitive regulation (Alanazi et al., 2025; Alanazi et al., 2024; Halim & Wulandari, 2024).

Discovery Learning, when implemented in isolation, may not optimally support the development of higher-order thinking skills. Several studies have reported that students often require structured guidance to connect observations with underlying concepts, evaluate evidence critically, and justify their reasoning (Khan & VanWynsberghe, 2020). Therefore, instructional models that combine student autonomy with systematic scaffolding are increasingly viewed as more effective alternatives for fostering critical thinking skills in secondary education.

In this context, innovative learning models that integrate inquiry-based and discovery-oriented approaches have gained attention. One such model is the Mordiscvein learning model, designed to enhance students' cognitive engagement through structured learning stages. The Mordiscvein model synthesizes elements of inquiry learning, such as problem formulation, hypothesis generation, and evidence evaluation, with discovery-based activities that promote exploration and conceptual understanding (Higueras-Rodríguez et al., 2020; Laliyo et al., 2020; Widiastuti et al., 2020). Through this integration, the model seeks to address the cognitive gaps often observed in traditional discovery learning implementations.

The Mordiscvein learning model integrates structured problem orientation, collaborative inquiry, experimentation, and reflective discussion to support the development of analytical reasoning, argumentation, inference, and decision-making. By balancing student-centered exploration with explicit cognitive scaffolding, the model aligns with higher-order thinking frameworks that conceptualize critical thinking as a multidimensional construct (Saleh et al., 2022, 2025; Saleh & Hasim, 2023). Despite its theoretical promise, empirical evidence on the effectiveness of the Mordiscvein model remains limited, particularly in comparative studies with established approaches such as discovery learning, thereby highlighting a clear research gap addressed in this study.

In addition, many previous studies examine multiple dependent variables simultaneously, which can dilute analytical depth and limit interpretative clarity. While affective outcomes such as motivation and self-confidence are undoubtedly important, focusing on a single cognitive outcome enables more rigorous measurement, analysis, and discussion. Given the central role of critical thinking in contemporary educational goals, a focused investigation on this variable is both timely and necessary.

Therefore, this study examines the effect of the Mordiscvein learning model on students' critical thinking skills compared with discovery learning. The study focuses on critical thinking as the dependent variable, allowing a clearer analysis of students' cognitive improvement based on established critical thinking indicators. The findings are expected to provide empirical evidence on the potential of the Mordiscvein model to support the development of students' critical thinking skills in biology learning.

RESEARCH METHODS

Study Design

This study employed a quantitative, quasi-experimental research design with a pretest–posttest control group. The design was selected to examine the causal effect of the Mordiscvein learning model on students' critical thinking skills by comparing learning outcomes between an experimental group and a control group. The experimental group received instruction using the Mordiscvein learning model, while the control group was taught using discovery learning. Both groups were administered a pretest before the intervention and a posttest after the intervention to measure changes in students' critical thinking skills.

Research Location

The research was conducted at SMAN 9 Bandar Lampung, a public senior high school in Bandar Lampung, Indonesia. The school was selected because it had implemented the Merdeka Curriculum and commonly applied discovery learning as an instructional model, making it relevant for comparing the Mordiscvein learning model. The participating classes had comparable learning environments, curriculum structures, and instructional schedules, ensuring consistency during the research implementation.

Selection of Participants

The population of this study consisted of all eleventh-grade science-track students at the research site during the academic year. A cluster-random sampling technique was used because the classes had already been administratively formed by the school. The sample consisted of 72 students from two intact classes, with 36 students in the experimental group and 36 in the control group. The experimental group was taught using the Mordiscvein learning model, while the control group received instruction using discovery learning. Students who did not complete both the pretest and posttest were excluded from the data analysis.

Procedure

The intervention lasted four weeks and consisted of eight 90-minute instructional sessions. Before the intervention, both groups completed a pretest to measure their initial critical thinking skills. The experimental group was taught using the Mordiscvein learning model, which emphasizes problem orientation, collaborative inquiry, structured experimentation, data interpretation, and reflective discussion. The control group received instruction using discovery learning following common steps such as stimulation, problem identification, data collection, data processing, verification, and generalization. Both groups studied the same content and were allocated equal instructional time. After the intervention, a posttest was administered to measure students' critical thinking skills.

Data Collection

Data were collected using test and non-test instruments. The primary instrument was a critical thinking skills test, administered as a pretest and posttest to measure students' cognitive development before and after the instructional intervention. In addition, a self-confidence questionnaire and documentation (photos and videos) were used to support the research process.

The critical thinking test was developed based on the framework proposed by Robert H. Ennis, which includes five main indicators: (1) elementary clarification, (2) basic support, (3) inference, (4) advanced clarification, and (5) strategy and tactics. These indicators were operationalized into specific sub-skills, such as focusing on questions, analyzing arguments, identifying assumptions, evaluating sources, drawing inferences, and making decisions (Ennis, 1996).

Data Analyze

The instrument consisted of 15 multiple-choice items developed based on a test blueprint that aligned biology learning objectives with critical thinking indicators. Each correct answer was scored 1 and each incorrect answer was scored 0, with the final score calculated using the correction formula

$$S = R - \frac{W}{(n-1)}$$

where R represents the number of correct answers, W the number of incorrect answers, and n the maximum score per item. Students' critical thinking levels were categorized based on percentage scores: 86–100 (Very Good), 76–85 (Good), 60–75 (Fair), 55–59 (Poor), and 0–54 (Very Poor). Content validity was established through expert judgment to ensure alignment between the test items, curriculum content, and critical thinking indicators. Construct validity was analyzed using the point-biserial correlation. Of the 15 items tested, 10 were declared valid and retained for the final instrument, while 5 items were excluded. Reliability testing using Cronbach's alpha produced a coefficient of 0.869, indicating very high reliability.

Item discrimination and difficulty indices were also examined to evaluate the quality of the instrument, and the retained items met acceptable criteria. The collected data were analyzed using descriptive and inferential statistics. Descriptive statistics were used to determine the mean, standard deviation, and score distribution of students' critical thinking skills. Prior to hypothesis testing, normality and homogeneity tests were conducted, followed by an independent samples *t*-test to examine differences in posttest scores between the experimental and control groups at a significance level of 0.05. Statistical analyses were performed using SPSS software.

Research Hypothesis

H_0 : There is no significant difference in students' critical thinking skills between those taught using the Mordiscvein learning model and those taught using discovery learning.

H_1 : There is a significant difference in students' critical thinking skills between those taught using the Mordiscvein learning model and those taught using discovery learning.

RESULTS AND DISCUSSION

Descriptive Statistics of Students' Critical Thinking Skills

Descriptive statistics of students' critical thinking skills in the experimental and control groups are presented based on the pretest and posttest scores. A summary of these results is presented in **Table 1.** These data provide an overview of students' critical thinking performance before and after the learning intervention.

The data presented in **Table 1** indicate that both groups initially had relatively low levels of critical thinking skills before the intervention. After the instructional treatment, both groups showed a substantial improvement in their scores. However, the experimental group achieved a higher mean posttest score than the control group.

Improvement of Critical Thinking Indicators in the Experimental Group

A more detailed overview of students' cognitive development is reflected in the improvement of each critical thinking indicator. The results are summarized in **Table 2** based on the experimental group's pretest and posttest scores. These data indicate the extent to which each indicator of critical thinking skills improved after the learning intervention.

Consistent improvement across all indicators of critical thinking was observed after the implementation of the Mordiscvein learning model, as shown in Table 2. All N-Gain values fall within the high category. These results indicate that the instructional model enhanced students' higher-order thinking skills.

Inferential Statistical Analysis

An independent-samples t-test was conducted to determine whether the difference in posttest scores between the experimental and control groups was statistically significant. The analysis revealed a p-value of 0.000, which is lower than the predetermined significance level of 0.05. This result indicates a statistically significant difference in students' critical thinking skills between the two groups.

The experimental group achieved a higher mean posttest score (84.37) than the control group (76.42). This indicates that the Mordiscvein learning model was more effective than discovery learning. It had a stronger impact on students' critical thinking skills.

Table 1. Mean scores of students' critical thinking skills

Group	Test Type	Mean Score
Experimental (Mordiscvein)	Pretest	12.40
Experimental (Mordiscvein)	Posttest	84.37
Control (Discovery Learning)	Pretest	12.40
Control (Discovery Learning)	Posttest	76.42

Table 2. Improvement of critical thinking indicators in the experimental group

Indicator of Critical Thinking	Pretest (%)	Posttest (%)	N-Gain
Identifying phenomena	50	88	0.76
Identifying assumptions	44	88	0.78
Explaining scientific phenomena	43	88	0.79
Presenting scientific evidence	52	87	0.73
Drawing conclusions	48	87	0.75

Overall, the results indicate that the Mordiscvein model was more effective in improving students' critical thinking skills. Students in the experimental group showed greater improvements in both overall scores and across individual indicators compared to the control group. These findings were further supported by statistically significant differences in posttest performance, confirming the model's stronger impact.

The results indicate that students taught using the Mordiscvein model achieved significantly higher critical thinking scores than those taught using discovery learning. This finding suggests that the Mordiscvein model provides instructional advantages beyond conventional discovery-based approaches. In particular, the model appears to better support the development of higher-order cognitive skills.

The significant difference between the experimental and control groups supports constructivist learning theory, which emphasizes active engagement through structured interactions and guided experiences. Although discovery learning is rooted in constructivism, minimal guidance may not sufficiently support complex cognitive processes such as critical thinking. The Mordiscvein model appears to operationalize constructivist principles more effectively by integrating structured inquiry and reflective reasoning into the learning process.

Critical thinking is widely recognized as a multidimensional construct involving problem identification, analysis, evaluation, inference, and decision-making (Agustira et al., 2025; Ananda et al., 2025; Tyas et al., 2023). The consistent improvement across all indicators suggests that the Mordiscvein model supports the comprehensive development of these dimensions. This finding aligns with theoretical frameworks proposed by Ennis and Facione, which emphasize the importance of instructional strategies that engage students in reasoning, justification, and reflection.

The superior performance of the experimental group may be attributed to the structured learning phases embedded in the Mordiscvein model. Unlike discovery learning, which often emphasizes exploration without explicit cognitive guidance, the Mordiscvein model integrates stages that require students to articulate problems, analyze evidence, and reflect on conclusions. These stages reduce cognitive ambiguity and allow students to focus on higher-order reasoning rather than procedural uncertainty, a concern frequently associated with unguided discovery approaches.

Table 3. Contribution of each stage of the modiscvein model to critical thinking development

Stage of Mordiscvein	Contribution to Critical Thinking	Comparison with discovery learning	Supporting References
Problem Orientation	Stimulates analytical thinking through structured problem identification and question formulation. Activates prior knowledge and promotes cognitive engagement.	Discovery Learning begins with stimulation, but problem framing is often less structured, which may limit the depth of analysis.	Ditingki et al. (2025); Wang et al. (2022)
Collaborative Inquiry	Enhances inference, argumentation, and evaluation through peer discussion and justification of ideas.	Discovery Learning may emphasize individual exploration, reducing opportunities for structured argumentative dialogue.	Demircioglu et al. (2023); Kuhn (2019); Rapanta et al. (2013)
Structured Experimentation	Strengthens evidence-based reasoning by guiding systematic data collection and hypothesis testing.	Discovery Learning includes experimentation, but often with less explicit scaffolding, which can lead to procedural focus.	Amiruddin et al. (2025); Kirschner et al. (2006); Lazonder & Harmsen (2016)
Data Interpretation	Develops analytical and evaluative skills through guided interpretation and conceptual linkage.	Interpretation in discovery learning may be less guided, increasing the risk of fragmented understanding.	Darling-Hammond et al. (2020); OECD (2019)
Reflective Discussion	Promotes metacognitive regulation and evaluative judgment through structured reflection and synthesis.	Reflection is not always systematically embedded in discovery learning.	Donker et al. (2014); Zohar & Barzilai (2013)

Table 3 illustrates how each stage of the Mordiscvein model systematically supports different dimensions of critical thinking, ranging from analytical reasoning and evidence-based evaluation to metacognitive regulation. The comparison with discovery learning highlights that structured scaffolding at each stage is crucial for fostering deeper cognitive engagement.

These conceptual distinctions align with prior empirical findings that report varying levels of effectiveness of discovery learning in promoting critical thinking skills. Previous studies have reported mixed results regarding the effectiveness of discovery learning in enhancing critical thinking skills (Rahayuningsih et al., 2024). While some research suggests that discovery-based approaches can promote conceptual understanding, others indicate that students may struggle to construct valid arguments or draw logical conclusions without sufficient scaffolding (Hakim et al., 2024; Noviyanto & Wardani, 2020; Santoso et al., 2024). The findings suggest that discovery learning alone may not adequately support students' critical thinking development in secondary education

The Mordiscvein learning model addresses this limitation by incorporating guided inquiry elements that help students connect empirical observations with theoretical concepts. This guided structure aligns with cognitive load theory, which posits that instructional designs should minimize extraneous cognitive load to

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optimize learning (Chen et al., 2023; Sweller et al., 2011). By providing clear learning stages and cognitive prompts, the Mordiscvein model reduces unnecessary cognitive demands, enabling students to allocate more mental resources to analysis and evaluation.

The high N-Gain values observed across all critical thinking indicators further reinforce the effectiveness of the Mordiscvein learning model. Indicators such as identifying assumptions and drawing conclusions showed substantial improvement, suggesting that students were better able to engage in analytical reasoning and synthesis. These skills are central to critical thinking and are often cited as key outcomes of effective inquiry-based instruction.

The findings of this study are consistent with previous research on guided inquiry and hybrid learning models. Several studies have demonstrated that instructional approaches combining exploration with structured guidance are more effective in promoting critical thinking than purely student-led discovery methods (Antonio & Prudente, 2023; Chen & Kalyuga, 2020; Lazonder & Harmsen, 2016). The Mordiscvein model contributes to this body of research by offering a concrete instructional framework that systematically integrates discovery and inquiry elements.

From a pedagogical perspective, the results highlight the importance of instructional design in fostering critical thinking skills. Active learning alone is insufficient without opportunities for reflection, argumentation, and evaluation (Chen & Kalyuga, 2020; Dewi et al., 2020). The Mordiscvein model appears to create a learning environment that encourages students to question assumptions, analyze evidence, and justify conclusions, thereby supporting deeper cognitive engagement.

The implications of these findings extend beyond the immediate research context. Although discovery learning is widely promoted as a student-centered approach in contemporary curricula, its implementation requires careful evaluation. The Mordiscvein model offers an alternative approach that balances learner autonomy with structured instructional guidance to better support students' cognitive development.

Focusing on critical thinking as the sole dependent variable was a deliberate methodological choice that strengthened the analytical depth of this study. This focus allowed a clearer examination of how the Mordiscvein learning model influences students' higher-order cognitive development. The results therefore provide more specific insight into the model's contribution to critical thinking enhancement.

Despite its contributions, this study has several limitations. First, the research was conducted in a single school setting, which may limit the generalizability of the findings to other educational contexts. Second, the sample size was relatively small, involving only two intact classes, and larger-scale studies are needed to confirm the robustness of these results.

Another limitation relates to the relatively short intervention period. Although significant improvements in critical thinking were observed, the long-term sustainability of these gains remains uncertain. In addition, the study relied exclusively on quantitative measures, which may not fully capture the complexity of students' reasoning processes.

Future research should examine the application of the Mordiscvein learning model across different subject areas to evaluate its adaptability and disciplinary relevance. Comparative studies involving other instructional models may also provide deeper insight into their relative effectiveness. Further research is encouraged to explore the role of teacher facilitation and instructional implementation in ensuring successful classroom application.

The findings provide empirical support for the effectiveness of the Mordiscvein learning model in enhancing students' critical thinking skills. By moving beyond traditional discovery learning, the model offers a structured yet flexible approach that aligns with contemporary learning theories. These results contribute to the growing body of research on guided inquiry and hybrid instructional models for developing higher-order thinking in secondary education.

CONCLUSION

This study examined the effect of the Mordiscvein learning model on secondary students' critical thinking skills in biology compared with discovery learning. The results demonstrate that students exposed to the Mordiscvein model achieved significantly higher critical thinking scores, indicating the effectiveness of structured inquiry combined with systematic scaffolding. These findings suggest that integrating guided problem orientation, structured experimentation, and reflective discussion can more effectively support the development of higher-order thinking skills than less-structured discovery approaches. The study provides empirical evidence for the growing body of research emphasizing the importance of guided instructional models in fostering critical thinking in science education contexts.

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