

## PAPER

# Effectiveness of Hybrid Discovery Learning in Enhancing Students' Comprehension and Critical Thinking Skills

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**ABSTRACT**

This study sought to explore how the hybrid discovery learning (HDL) model can support and enhance students' comprehending of the material. In particular, it examined the differences in learning outcomes when the HDL approach was implemented with and without the support of a learning management system (LMS). A quasi-experimental design with a descriptive quantitative approach was employed, involving three cohorts: two control cohorts and one experimental cohort. Data were gathered through an assessment of students' critical thinking skills in a secondary school history class. The results indicated that both forms of the HDL model, whether implemented in a conventional setting or supported by an LMS, contributed significantly to enhancing students' comprehension. The experimental cohort and Control cohort 2 outperformed Control cohort 1, which was taught using the direct instruction model. However, LMS integration did not yield significant additional benefits. These findings affirm the effectiveness of the HDL model in improving student learning outcomes and offer meaningful insights that can inform the design and implementation of more impactful active learning strategies in the future.

**KEYWORDS**

hybrid discovery learning (HDL) model, learning management system (LMS), critical thinking skills, student comprehending, direct instruction, active learning

## 1 INTRODUCTION

The rapid advancement of digital technology has profoundly transformed education systems around the world. According to the *UNESCO Global Education Monitoring Report* [1], nearly 80% of education systems have now adopted strategies to integrate digital tools into teaching and learning processes. During the COVID-19 pandemic, the closure of schools disrupted the education of nearly 1.6 billion

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learners in over 190 countries, affecting approximately 94% of the global student population [2]. This unprecedented disruption underscores that online and hybrid learning are no longer optional but have become essential strategies to sustain educational continuity, accessibility, and equity worldwide. The growing integration of technology-based learning reflects the evolving nature of modern education, which places a strong emphasis on technological innovation as a core component of the learning process [3], [4]. As facilitators of learning, teachers are expected to develop the capacity to effectively navigate both traditional face-to-face instruction and digital or hybrid learning environments [5], [6]. By combining in-person classroom instruction with online platforms, hybrid learning has emerged as a widely adopted approach in contemporary education [7]–[9]. Additionally, synchronous and asynchronous online learning can be implemented [8], [10]. Given the profound impact of online learning during the COVID-19 pandemic, there is a growing need for a coordinated approach that integrates contemporary and context-based learning objectives aligned with the demands of 21st-century education. In this regard, blended learning serves as an effective alternative, offering students greater flexibility to adapt to diverse learning contexts and circumstances [11], [12]. In modern education, students are expected to engage in contextual learning, and discovery learning has proven to be an effective model for fostering this process.

This shift toward more flexible and context-based learning approaches underscores the importance of adapting pedagogical models across diverse disciplines, including history education. Such transformations within the education system carry significant implications for the ways in which history is studied and taught [13]. In this context, students engaged in history education can be positioned as historians, aligning with the principles of context-based and inquiry-driven learning. Historians not only reconstruct the past but also interpret it through the lens of the present [13], [14]. Accordingly, the study of history necessitates that accounts of past events be constructed on the basis of credible historical evidence, guided by a clear comprehension of the motivations for seeking such evidence, and supported by interpretive frameworks informed by both primary observations and secondary sources [15], [16]. The concept of historiography, which emphasizes the interaction between the subject (history) and the object (evidence), reflects critical theory perspectives [17]. This underscores the urgency of rethinking history education within today's digital and hybrid learning contexts, ensuring that students not only acquire factual knowledge but also cultivate critical thinking and contextual interpretation skills that are essential for 21st-century learning.

Critical thinking in history refers to the cognitive strategies and dispositions that enable learners to engage with and comprehend historical knowledge in its proper context. Effective historical analysis requires recognizing that researchers' inquiries and hypotheses play a pivotal role in forming both the investigative process and the resulting interpretations [18]. Previous studies have highlighted that interactive, student-centered learning approaches offer clear advantages in fostering active engagement, enhancing contextual relevance, and creating more stimulating learning experiences [19]. Likewise, instruction that accommodates individual learning styles has the opportunity to enhance the standard and effectiveness of teaching [20], [21]. Comprehending these learning styles provides teachers with an important reference point when selecting instructional strategies [22]. Moreover, experiential learning environments have been shown to foster diverse learning experiences, allowing students to construct knowledge in ways that align with their individual needs [23], [24].

However, despite these valuable insights, existing literature tends to emphasize the advantages of discovery-based and experiential approaches without sufficiently

addressing how these methods can be systematically integrated into digital and hybrid learning environments. Moreover, research explicitly connecting historical learning with models such as the hybrid discovery learning (HDL) model that integrates inquiry, contextual interpretation, and technology-enhanced instruction remains scarce. This gap underscores the need for further studies that critically examine the role of the HDL model in fostering students' critical thinking within history education, particularly in hybrid or blended learning contexts.

The HDL Model [25] was developed by Nadjamuddin, combining the principles of Bruner's discovery learning and Martyn's hybrid learning [26], [27] with a structured procedure in several stages involving collaborative student and teacher activities (refer to Table 1).

**Table 1.** Syntax of HDL model

Syntax	Teacher's Activities	Student's Activities
Stimulation	The teacher begins by activating students' prior knowledge through apperception or guided recall.	Students take turns sharing information drawn from their personal experiences or observations.
Problem Statement	The teacher presents case examples of essential topics.	Students listen attentively to the teacher's explanation.
Reinforcement Theory	The teacher explains the learning material using media such as videos or images.	Students attentively listen to the teacher's explanation.
Online Learning Strategies	The teacher provides instructions on the synchronous and asynchronous stages of online learning for future sessions.	Pupils carefully heed and adhere to the educator's directions.
Data Collection	The teacher distributes learner worksheets to guide students in collecting data through interviews, observations, and literature reviews.	The students collect data through interviews, observations, and literature reviews conducted either within their immediate environment or at designated observation sites.
Data Processing	The teacher prepares data processing tables to help students organize and interpret their findings in a structured and systematic way.	Students input data into the Student Worksheets.
Verification	The teacher verifies students' opinions based on their findings.	After gathering information, students compare their findings with their initial viewpoints, which were shaped by the teacher's introductory concepts at the beginning of the lesson.
Drawing Conclusions/Generalization	The teacher reviews students' conclusions and prepares discussion materials to clarify, enrich, and relate their findings to broader phenomena.	Students formulate preliminary conclusions based on their findings, initial theoretical comprehension, and personal perspectives.
Synchronous Discussion of Findings	The teacher prepares a video conference platform for the discussion session.	Students follow the teacher's instructions to prepare cohort discussion materials and set up video conferencing tools.
	The teacher allows each team to showcase their research results.	Student cohorts present their findings concisely and informatively.
	Students follow the teacher's instructions to prepare cohort discussion materials and set up video conferencing tools.	Student cohorts prepare questions and clarifications for each other.
Asynchronous Discussion	The teacher prepares a platform for continued discussion through chat.	Students engage in additional discussions using social media cohorts.
Collection of Findings with Discussion Input	The teacher prepares a paper format for students, along with discussion panel findings.	Students submit their findings paper, enriched with cohort discussions and feedback by the teacher.
	The teacher reflects on the learning outcomes as a reference for future lessons.	

The enhancement of this model is grounded in previous studies that have separately examined the effectiveness of discovery learning [26], [28] and hybrid learning [7], [8], [29]. Discovery learning has been shown to foster active student engagement and promote independent conceptual comprehending, while blended learning has proven effective in offering greater flexibility and expanding access to education. However, research that explicitly integrates these two approaches into a unified model, particularly within the context of history education, remains scarce [30]. Moreover, the added value of integrating a learning management system (LMS) into the HDL model framework has not yet been extensively explored through comprehensive empirical research [31].

Therefore, this study has the objectives to examine the effectiveness of the HDL model in enhancing secondary school students' comprehension and critical thinking skills, both with and without the integration of an learning management system.

Based on these objectives, the following research questions were patterned:

1. Does the HDL model significantly improve students' comprehension and critical thinking skills contrasted to the direct instruction model?
2. Does the integration of an LMS into the HDL model lead to greater improvements in students' comprehension and critical thinking skills contrasted to the HDL model without LMS support?

## 2 LITERATURE REVIEW

### 2.1 Hybrid discovery learning

The HDL model represents an evolution of the classic discovery learning approach. A meta-analysis further concluded that guided discovery learning is more effective in enhancing learning outcomes contrasted to either pure discovery learning or explicit instruction [28]. This finding served as a foundation for the enhancement of the HDL model, which seeks to balance structured guidance with opportunities for independent discovery. Furthermore, a meta-analysis on the effectiveness of guidance in inquiry-based learning revealed that well-designed instructional support can significantly enhance students' performance, knowledge acquisition, and problem-solving abilities [32].

Technology integration is a defining feature of the HDL model. Recent studies on hybrid learning supported by mobile interaction technology have shown that combining online and offline learning resources can foster real-time and flexible interactions, thereby enhancing learning outcomes and engagement [33]. Findings by studies on the use of virtual laboratories in science learning indicate that digital tools can enrich students' discovery experiences and support a deeper comprehension of complex concepts [34]. Boelens et al. [12] identified challenges and strategies in designing effective blended learning environments, emphasizing the importance of flexibility, interaction, and facilitation of self-directed learning in the context of the HDL model.

### 2.2 Student comprehending

Student comprehending is one of the main variables influenced by the HDL model. Hmelo-Silver et al. [35] emphasized the importance of scaffolding in

facilitating effective discovery learning. They argued that well-designed support can enable students to overcome cognitive constraints and foster a deeper conceptual understanding. Pedaste et al. [36] proposed a framework for inquiry-based learning that can be implemented in the context of the HDL model. This framework encompasses five key phases orientation, conceptualization, investigation, conclusion, and discussion that offer a structured foundation for designing HDL model experiences that effectively enhance students' comprehension. Furtak et al. [37], in a meta-analysis of inquiry-based science learning, showed that teacher-led approaches were more effective than those that were entirely student-led. This finding reinforces the HDL model, which integrates structured guidance with opportunities for independent discovery to deepen students' comprehension.

### 2.3 Critical thinking

Facione [38] defines critical thinking as purposeful and purposeful judgment involving interpretation, analysis, evaluation, and inference. Several recent studies have reaffirmed the crucial role of critical thinking in education. For instance, a quasi-experimental study demonstrated that interface instrumentation experiments-supported blended learning (IIE-BL) significantly improved students' critical thinking skills and academic achievement compared to conventional instruction, highlighting the effectiveness of technology-integrated hybrid approaches in fostering higher-order thinking [39]. In line with this, Pedaste et al. proposed an inquiry-based learning model designed to foster the enhancement of higher-order reasoning skills [36]. Lazonder and Harmsen underscore the pivotal role of teacher guidance in discovery learning, highlighting its contribution to fostering students' reasoning abilities [32]. However, Hmelo-Silver et al. identified a gap in the literature correlating the specific impact of the HDL model on students' critical thinking [35]. This indicates that, while numerous studies have emphasized the advantages of discovery learning, blended learning, and teacher guidance, there is still a notable gap in research that specifically explores how these elements can be integrated within the HDL model framework to support the enhancement of students' critical thinking skills.

### 2.4 Synthesis and research gaps

Based on the reviewed literature, several limitations can be identified. First, most existing studies have examined discovery learning and blended learning as separate approaches, with relatively few exploring their integration through the HDL model. Second, although existing studies emphasize the importance of teacher guidance and scaffolding, there is limited comprehension of how this balance can be effectively optimized in hybrid learning environments to enhance both students' comprehension and critical thinking skills. Third, the integration of technology, particularly LMS, within the HDL model has not yet been extensively explored through empirical research. This gap highlights the need for further studies to examine the effectiveness of the HDL model in strengthening students' critical thinking skills, especially in the context of history education.

**Table 2.** Summary of previous studies on discovery, blended, and hybrid learning

Author/Year	Objective	Method	Main Results	Limitations
Hmelo-Silver et al., 2007 [35]	To analyze scaffolding in discovery learning	Literature review	Scaffolding supports overcoming cognitive limitations and enhances comprehension	Did not address hybrid or technology-integrated contexts
Furtak et al., 2012 [37]	To evaluate inquiry-based science learning	Meta-analysis	Teacher-led inquiry is more effective than fully student-led approaches	Focused on science learning, not implemented in history or hybrid contexts
Boelens et al., 2017 [12]	To identify strategies in blended learning	Qualitative study	Flexibility, interaction, and self-directed learning are key in blended models	Did not specifically analyze critical thinking outcomes
Lazonder and Harmsen, 2016 [32]	To examine the effectiveness of teacher guidance in discovery learning	Meta-analysis	Teacher guidance significantly improves student reasoning skills	Limited focus on HDL framework
Pedaste et al., 2015 [36]	To propose a framework for inquiry-based learning	Conceptual framework	Provided five phases for effective inquiry learning	Lacked empirical testing in hybrid discovery contexts

### 3 RESEARCH METHODOLOGY

#### 3.1 Research design

The HDL model developed by [25] serves as the independent variable, while students' critical thinking abilities constitute the dependent variable. The study follows a descriptive quantitative statistical approach with a quasi-experimental design. The study employs a non-equivalent control cohort design to examine the impact of the HDL model across different classes. This design allows for the comparison between control and experimental cohorts by measuring students' critical thinking skills both before and after the intervention. Through this approach, the study seeks to capture changes attributable to the implementation of the HDL model [40]. The implemented HDL model in the experimental class is expected to influence students' critical thinking abilities significantly. The sample consists of two control classes and one experimental class. The first control class did not receive any treatment, serving as a baseline for comparison. The second control class was exposed to the HDL model, while the third class received the same HDL treatment combined with the integration of an LMS tailored to support the model. By comparing the outcomes across these three cohorts, the study has the objective to assess the effectiveness of the HDL model and examine the opportunity added value of incorporating LMS technology into the learning process.

#### 3.2 Sample

The sample comprised senior high school students from selected schools in Tolitoli Regency. Participants were recruited through a random sampling technique by schools that demonstrated strong academic performance and possessed well-equipped learning environments. In total, 105 students participated voluntarily in the study, consisting of approximately 56.2% female and 43.8% male students.

The research sites were selected based on the outcomes of *2019 Teacher Competency Assessment*, which highlighted regions with strong performance in teaching implementation. By focusing on schools with high competency levels, this study

sought to examine the effectiveness of the HDL model and assess the opportunity influence of integrating an LMS across varied educational contexts. The site selection also took into account each school's readiness to support the research through adequate technological infrastructure for both teachers and students. This ensured the smooth implementation of the LMS throughout the three-week research period.

### 3.3 Data collection

Conceptual and operational definitions were established for the critical thinking variable, serving as the foundation for developing the assessment instrument. Critical thinking skills were measured at two-time points, pre-test and post-test, following the structure of a quasi-experimental design. Data collection was centered on evaluating high school students' critical thinking abilities in history using two instruments: (1) a validation tool to confirm the reliability and validity of the critical thinking assessment and (2) a measurement tool designed to capture students' levels of critical thinking proficiency.

All assessments were conducted under standardized conditions and closely supervised by trained research assistants to maintain consistency, minimize opportunity biases, and ensure the accuracy of the collected data.

### 3.4 Analyzing of data

The data analysis in this study is carried out through several systematic techniques. First, the validation data for the high-level thinking ability and learning outcomes assessment instruments are examined using Aiken's V formula. This approach is implemented to calculate the content validity coefficient, ensuring that each item accurately reflects the construct it is intended to measure [41]. This process plays a crucial role in establishing both construct and item validity for the 105 participating students. Following this stage, the researchers analyze the data obtained by the assessment of students' critical thinking skills to evaluate the effectiveness of the HDL model. The analysis employs parametric statistical methods, with the gain score equation used to calculate improvements in students' performance. Additionally, a normality test was performed using the Kolmogorov–Smirnov Test to examine whether the data were normally distributed. This step is essential to ensure that the assumptions underlying the statistical analyses are met. By applying these analytical procedures, researchers can draw more accurate and meaningful conclusions correlating the effectiveness of the HDL model in improving students' critical thinking skills. Furthermore, these tests help confirm the validity and reliability of the assessment instruments employed in the study, thereby strengthening the overall rigor of the research.

In the validity test (refer to Table 3), the mean scale values range from 4.5146 to 5.4369. A mean score that closely aligns with the original scale indicates stronger item validity. When specific items are excluded, the variance scale falls between 3.714 and 4.291. A higher variance suggests greater variability in respondents' answers to those items, reflecting more diverse perceptions or interpretations. In contrast, lower variance values typically correspond to more stable and valid items. Furthermore, the corrected item–total correlation coefficients range from 0.19 to 0.354. Higher correlation values demonstrate that these items are more strongly associated with the overall critical thinking score, indicating their greater contribution to the construct being measured.

**Table 3.** Item validity

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ITEM_01	5.4369	4.288	0.300	.	0.634
ITEM_02	5.4272	4.286	0.251	.	0.636
ITEM_03	5.4272	4.247	0.301	.	0.632
ITEM_04	5.3786	4.042	0.354	.	0.621
ITEM_05	5.4078	4.263	0.213	.	0.638
ITEM_06	5.3495	3.994	0.332	.	0.622
ITEM_07	5.301	3.918	0.317	.	0.623
ITEM_08	5.233	3.965	0.225	.	0.639
ITEM_09	5.1456	3.714	0.328	.	0.621
ITEM_10	5.0388	3.646	0.334	.	0.62
ITEM_11	5	3.824	0.230	.	0.643
ITEM_12	4.767	3.729	0.328	.	0.621
ITEM_13	4.5728	4.188	0.190	.	0.641
ITEM_14	4.5243	4.232	0.246	.	0.635
ITEM_15	4.5146	4.291	0.210	.	0.639

**Table 4.** Reliability statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.647	0.674	15

Based on Table 4, the measurement instrument produced a Cronbach's alpha value of 0.647, indicating a reasonably good level of internal reliability for the scale. This suggests that the items consistently measure the intended construct, namely students' critical thinking abilities. Nonetheless, there remains room for improvement, and revising or refining certain items may help enhance the instrument's reliability. When using standardized items, the Cronbach's alpha value increased slightly to 0.674. This marginal improvement suggests that standardization can help reduce measurement errors and improve the consistency of the items in assessing the target construct. In summary, both Cronbach's alpha values reflect an acceptable level of internal reliability for the measurement instrument, with the standardized items demonstrating a slight improvement in reliability contrasted to the non-standardized items. These results should be interpreted in relation to the overall objectives and context of the study. Further refinement of the instrument may enhance its internal consistency. Moreover, the findings confirm that the reliability threshold of 0.05 has been met and exceeded, reinforcing the robustness of the instrument used in this study.

## 4 RESULT

In Control cohort 1, a total of 36 participants completed both the pre-test and post-test assessments. The cohort's mean pre-test score was 5.42 with a standard deviation

of 1.87. In contrast, the mean post-test score increased to 7.44 with a standard deviation of 1.96 (refer to Table 5). The significance value (p-value) of 0.881 indicates that there is insufficient statistical evidence to reject the null hypothesis for Control cohort 1 (refer to Table 6). This suggests that the difference between the pre-test and post-test scores in this cohort is not statistically significant. In other words, the intervention implemented in Control cohort 1 did not produce a meaningful effect on student performance, as reflected in the minimal change in scores (refer to Table 5).

Control cohort 2, which comprised 34 paired pre-test and post-test samples, recorded a mean pre-test score of 5.62 with a standard deviation of 2.52. In comparison, the mean post-test score increased to 9.18 with a standard deviation of 1.96 (refer to Table 5). With a significance value of 0.032, there is sufficient statistical evidence to reject the null hypothesis for this cohort (refer to Table 6). This result indicates that the difference between the pre- and post-test scores is statistically significant. In other words, the intervention implemented in Control cohort 2 produced a notable improvement in student performance. Finally, the analysis focused on the Experimental cohort, which comprised 35 paired pre- and post-test samples. The mean pre-test score for this cohort was 5.43 with a standard deviation of 1.96 (refer to Table 5). In contrast, the mean post-test score increased to 9.09, accompanied by a standard deviation of 2.41 (refer to Table 5). With a significance value of 0.03, the results provide sufficient statistical evidence to reject the null hypothesis for the Experimental cohort (refer to Table 6), indicating that the intervention had a meaningful effect on student learning outcomes. This finding suggests that the difference in scores between the pre- and post-test for the Experimental cohort is statistically significant. In other words, the intervention administered to the Experimental cohort produced a meaningful improvement in students' performance, demonstrating a clear impact of the treatment on learning outcomes.

**Table 5.** Paired samples statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test Control 1	5.4167	36	1.87274	0.31212
	Post-test Control 1	7.4444	36	1.96315	0.32719
Pair 2	Pre-test Control 2	5.6176	34	2.5228	0.43266
	Post-test Control 2	9.1765	34	1.9613	0.33636
Pair 3	Pre-test Experimental	5.4286	35	1.95968	0.33125
	Post-test Experimental	9.0857	35	2.40553	0.40661

**Table 6.** Paired samples correlations

		N	Correlation	Sig.
Pair 1	Pre-test Control 1 & Post-test_Control_1	36	0.026	0.881
Pair 2	Pre-test Control 2 & Post-test Control_2	34	0.369	0.032
Pair 3	Pre-test Experiment & Post-test Experiment	35	0.366	0.03

**Table 7.** Significant test

No.	Class Cohort	N-Gain Score	Category
1	Control 1	0.2	Low
2	Control 2	0.4	Medium
3	Experiment	0.4	Medium

The study examined the enhancement of critical thinking skills through a comparative analysis involving three distinct learning cohorts: two control cohorts and one experimental cohort. Control cohort 1 implemented the Direct Instruction model, emphasizing structured teaching methods and the teacher’s direct delivery of learning materials. Following the intervention, this cohort recorded an N-Gain score of 0.2 (refer to Table 7), indicating a relatively modest improvement in students’ critical thinking skills. N-Gain reflects the difference between post-test and pre-test scores, illustrating a meaningful improvement in students’ comprehension within this class, which was initially categorized as low. Control cohort 2 implemented the HDL model, which integrates elements of discovery and guided learning. This approach offers students meaningful opportunities to actively engage in exploration and problem-solving activities. The evaluation results showed that this cohort achieved an N-Gain value of 0.4 (refer to Table 7), indicating a greater improvement in comprehension contrasted to Control cohort 1. The results indicate that the HDL model has a significant and moderately positive effect on students’ comprehending. The Experimental cohort implemented the HDL model with the support of an LMS, integrating technological features with inquiry-based learning. This approach enabled students to access learning content online and engage with the materials independently. The Experimental cohort achieved an N-Gain value of 0.4, identical to that of Control cohort 2 (refer to Table 7). These findings suggest that implementing the HDL model with LMS support is equally effective in enhancing students’ comprehension, yielding results comparable to those achieved by Control cohort 2.

The research findings indicate that both versions of the HDL model, whether implemented in its traditional form or supported by an LMS, effectively enhance students’ comprehension. In comparison, both Control cohort 2 and the Experimental cohort demonstrated greater improvements than Control cohort 1, which utilized the direct instruction learning model (refer to Table 8).

**Table 8.** Independent sample t-test

Compare Class		Levene's Test for Standard of Variances		t-Test for Standard of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Control Class 1 & 2	Assumption of equal variances	2.483	0.120	-3.410	68.000	0.001	-12.227	3.586	-19.383	-5.071
	Assumption of equal variances			-3.385	62.314	0.001	-12.227	3.612	-19.446	-5.008
Experimental Class &	Assumption of equal variances	0.002	0.963	-5.862	67.000	-	-23.188	3.956	-31.084	-15.293
Control Class 1	Assumption of equal variances			-5.858	66.631	-	-23.188	3.958	-31.090	-15.287
Control Class 2 &	Assumption of equal variances	3.290	0.074	-3.159	69.000	0.002	-10.961	3.470	-17.884	-4.038
Experimental Class	Assumption of equal variances			-3.149	65.501	0.002	-10.961	3.480	-17.911	-4.011

## 5 DISCUSSION

Twenty-first century learning carries significant implications for transforming the educational process. The COVID-19 pandemic has accelerated these changes, reinforcing the urgency of aligning teaching practices with modern learning objectives and the need for contextual comprehending. In this context, hybrid learning emerges as an effective alternative, offering greater flexibility and adaptability to accommodate diverse student needs and learning conditions [7], [9], [12], [42]. Furthermore, the demand for contextual learning aligns well with discovery learning, a model that facilitates student engagement in real-world problem solving [36].

The hybrid learning model was first introduced by Martyn [27], who transformed traditional face-to-face instruction into a blended educational approach that integrates both online and offline learning components. Subsequently, Tashiro et al. [43] presented five distinct types of hybrid learning to implement this evolved framework effectively. Furthermore, Yamagata-Lynch [44] introduced the term “blended learning,” that integrates synchronous and asynchronous learning methods to support distance education and incorporate a variety of instructional strategies. The theoretical foundation of discovery learning aligns well with hybrid learning, as both emphasize experiential, student-centered exploration that encourages active engagement with the learning process [9], [45].

Initially introduced by Bruner (1961), discovery learning emphasizes experiential learning through hands-on activities and data collection within real-world contexts [32]. This theory reinforces concepts taught in the classroom by contextualizing and demonstrating them in real-world situations. Over time, this theory underwent further enhancement, as proposed by Holland et al. [46], to include the enhancement of intangible knowledge frameworks, like principles and theories, through inductive logic, especially when dealing with concrete educational content. Hammer [47] also advocated a similar approach, integrating traditional content with investigation-oriented specialized agendas.

This study examines the effectiveness of three different instructional approaches in developing and enhancing students' critical thinking skills. The three learning cohorts contrasted in this study are Control Class 1, Control Class 2, and the Experimental Class. First, Control Class 1 implemented the Direct Instruction learning model, which emphasizes structured teaching through the direct presentation of material by the teacher. Following the intervention, this class demonstrated an improvement in comprehension, with an N-Gain value of 0.2. These findings indicate a measurable enhancement in students' comprehension as a result of this instructional approach. Second, Control Class 2 implemented the HDL model, which integrates elements of discovery and guided learning to foster more active student engagement and conceptual comprehension. This model provides students with meaningful opportunities to actively engage in exploration and problem-solving activities. The evaluation results indicate that Control Class 2 demonstrated greater improvement in comprehending contrasted to Control Class 1, with an N-Gain value of 0.4. These findings suggest that the HDL model effectively enhances students' comprehension. Furthermore, the Experimental Class implemented the HDL model with the support of an LMS, integrating technology to further facilitate the learning process. This model integrates technological features with discovery-based learning, enabling students to access learning materials online and engage with the content independently. The findings indicate that the Experimental Class achieved an improvement in comprehension equivalent to that of Control Class 2, with an

N-Gain value of 0.4. These results suggest that the use of an LMS to support the HDL model produces learning outcomes comparable to those of the HDL model implemented without LMS support.

The analytical process in this study utilized Levene's Test to assess the homogeneity of variances and t-tests to examine mean differences across the study cohorts. The results revealed significant differences among the cohorts contrasted. Specifically, comparisons between Control Class 1 and Control Class 2, between the Experimental Class and Control Class 1, and between Control Class 2 and the Experimental Class showed significant mean differences. These findings indicate that the HDL model, whether implemented conventionally or supported by an LMS, is more effective in enhancing students' comprehension compared to the Direct Instruction model implemented in Control Class 1. Furthermore, the significant difference between Control Class 2 and the Experimental Class indicates that the use of an LMS to support the HDL model does not offer additional advantages in enhancing students' critical thinking skills. However, it is important to recognize the limitations of this study. Factors such as learner characteristics and educational settings may have influenced the outcomes. Therefore, further research with larger sample sizes and more comprehensive analyses is recommended to gain a deeper understanding of the factors that contribute to improving students' learning outcomes across different instructional approaches.

This study contributes to the enhancement of more effective learning approaches and deepens our comprehension of various teaching methods within educational contexts. The practical implication is that teachers and educational decision-makers may consider implementing the HDL model, with or without LMS support, to enhance students' comprehension. Previous studies have explored a range of instructional methods and their effects on student learning outcomes. Many of these studies highlight that approaches involving active student participation, such as Discovery Learning, create meaningful opportunities for learners to engage in concept exploration and knowledge construction, ultimately leading to improved comprehension [32], [48], [49]. The findings by these studies indicate that student-centered learning, in that learners actively engage in exploring concepts and constructing their comprehension, can lead to stronger learning outcomes. In this context, students independently access digital resources, conduct interviews, and consult various references to examine the evolution of Dutch colonial rule in Indonesia. These findings align with previous research highlighting the important role of technology in education, particularly in enhancing student engagement, literacy, and comprehension [33], [50].

Moreover, the integration of technological solutions into academic settings has increasingly become a focal point of educational research. Studies examining the use of technology in learning environments have reported promising results. The implementation of Learning Management Systems (LMS) provides flexible and seamless access to educational resources while promoting greater autonomy and active student engagement with learning content [30], [51], [52]. Research also indicates that technology can enhance students' motivation, engagement, and learning outcomes [53]–[55]. The integration of synchronous and asynchronous learning modes has the opportunity to enhance student engagement and deepen comprehension. However, it also introduces challenges, particularly related to technological limitations and students' self-regulation abilities [56]. This finding aligns with the core principles of HDL, which emphasize the importance of balancing guided exploration with independent learning to optimize students' comprehension and critical thinking skills. In the context of this study, the HDL model that integrates elements

of discovery and guided learning, supported by the use of an LMS, offers a powerful combination of active student engagement with learning materials and convenient access to educational resources. Both Control Class 2 and the Experimental Class, which implemented the HDL model with or without LMS support, showed significant improvements in students' comprehending. These findings align with previous research that has revealed the effectiveness of the HDL model in enhancing students' comprehension [25], as well as the benefits of using technology in the learning context [57], [58].

## 6 CONCLUSION

The findings of this study confirm that the HDL model, whether implemented in its conventional form or supported by an LMS, is more effective than the Direct Instruction model in enhancing students' comprehension and critical thinking skills. Both HDL approaches resulted in greater learning gains, highlighting the advantages of discovery-oriented learning over traditional teacher-centered instruction.

While the integration of an LMS did not produce significant gains beyond those achieved through the conventional HDL model, it provided notable advantages in terms of accessibility and flexibility. This finding indicates that the LMS serves primarily as a complementary support system rather than a determining factor in student learning outcomes.

From a practical standpoint, educators can confidently implement the HDL model to foster deeper comprehension and strengthen students' critical thinking skills. The decision to integrate an LMS should be guided by contextual factors such as the availability of digital infrastructure and the level of student readiness. This study adds to the growing body of evidence supporting student-centered learning approaches and underscores the importance of striking a balance between guided discovery and independent exploration in 21st-century learning environments.

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