

Developing a Digital Learning Management Strategy Using the Dick and Carey Model to Enhance Junior High School Students' Critical Thinking in Biology Learning

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ABSTRACT

Biology learning at the junior secondary school level faces increasing challenges in fostering students' critical thinking skills as a core competency of the 21st century. International assessments consistently indicate that students' higher-order thinking skills in science remain relatively low, highlighting the need for learning strategies that emphasize systematic learning management rather than content transmission alone. This study aims to develop and examine the effectiveness of a digital learning management strategy through the integration of the Nearpod web-based platform using the Dick and Carey instructional design model to enhance junior high school students' critical thinking skills in Biology. This research employed a Research and Development (R&D) approach following the nine stages of the Dick and Carey model, including needs analysis, instructional analysis, learner analysis, instructional design, formative evaluation, revision, and field implementation. The participants consisted of 72 eighth-grade students, three Biology teachers, two media experts, and one educational technology expert. Data were collected through observations, questionnaires, critical thinking tests, interviews, and Nearpod learning analytics, and analyzed using qualitative techniques and gain score analysis. The results indicate an average increase of 26.8% in students' critical thinking skills (N-Gain 0.44), categorized as medium-high, demonstrating that systematically managed digital learning effectively supports higher-order cognitive processes. The study concludes that integrating Nearpod as a digital instructional management system within a coherent instructional design framework significantly enhances Biology learning quality. This research contributes theoretically by linking instructional design, digital learning management, and critical thinking development, and practically by offering an implementable model for technology-enhanced science instruction.

Keywords: *Biology Learning, Critical Thinking Skills, Dick and Carey Model, Digital Learning Management, Nearpod*



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INTRODUCTION

Biology learning at the junior high school (SMP) level faces increasingly complex challenges, along with the need to strengthen critical thinking skills as part of 21st-century competencies. Various international reports indicate that students' higher-order thinking skills remain relatively low, particularly in science subjects that require evidence-based reasoning and in-

depth conceptual understanding (OECD, 2019; OECD, 2023). This situation requires learning strategies that are not only oriented towards content mastery but also focus on systematic management of the learning process and focus on students' cognitive activities (Facione, 2015; Ennis, 2018).

The development of digital technology has opened up vast opportunities for transforming science learning, including biology. However, studies of educational technology emphasize that technology integration does not automatically improve learning quality without adequate instructional design and learning management (Kirkwood & Price, 2014; Selwyn, 2016). Many digital learning practices still position technology solely as a medium for delivering content, thus underutilizing its potential as a manager of learning activities, a monitor of cognitive processes, and a provider of learning data (Dede, 2018; Mayer, 2020).

In the context of biology learning, these challenges are even more pronounced due to the abstract, dynamic nature of the material, which is often difficult to visualize using conventional methods. Previous research has shown that the use of interactive media and digital simulations can improve science students' conceptual understanding and higher-order thinking skills, provided they are integrated into a well-planned learning strategy (Smetana & Bell, 2012; Mayer, 2020). Therefore, a systemic approach that integrates digital technology with strong learning design principles is needed (Henderson et al., 2020).

Nearpod is a digital learning platform with potential as a learning management system. This platform provides learning planning features, interactive presentation of materials, real-time monitoring of student responses, and learning analytics that support data-driven instructional decision-making (Fisher & Newton, 2020; Harpaz, 2021). Unlike conventional Learning Management Systems (LMS) such as Moodle or Google Classroom, which often function primarily as asynchronous repositories for material distribution, Nearpod allows for 'live session' management. This enables teachers to control the pace of learning, provide immediate feedback during the thinking process, and monitor student engagement synchronously—capabilities that are crucial for managing the complex cognitive steps in the Dick and Carey model. Although Nearpod has been extensively researched, most international research focuses on student engagement or perceived usability, and little has been done to examine Nearpod as part of a digital learning management strategy integrated with an instructional system design model, particularly in junior high school biology (Mandinach & Gummer, 2016; Bond et al., 2020).

To bridge this gap, a systematic framework is essential. The Dick and Carey model offers a learning systems design framework that emphasizes alignment between needs analysis, instructional objectives, learning strategies, and evaluation. Instructional design literature suggests that implementing a systemic model like Dick and Carey's contributes significantly to the success of digital learning by ensuring instructional coherence and constructive alignment between learning components (Reigeluth, 2013; Dick et al., 2015). However, empirical studies integrating the Dick and Carey model with web-based digital learning platforms in the context of junior high school biology learning are still relatively limited.

Although extensive research has been conducted on learning technology and critical thinking (Putra & Lestari, 2021; Wahyuni, 2022), studies integrating Nearpod into a digital learning management perspective based on the Dick and Carey model in junior high school biology learning are still limited. Most studies focus solely on media effectiveness or improving learning outcomes, without examining how technology is managed as part of a comprehensive learning system. Therefore, this study is crucial to fill this gap by analyzing digital learning management strategies through the integration of web-based Nearpod in an effort to improve junior high school students' critical thinking skills in biology learning.

Based on the above explanation, this research aims to develop and test a digital learning management strategy through the integration of web-based Nearpod with the Dick and Carey model to improve junior high school students' critical thinking skills in Biology learning. This

research lies in the integration of Nearpod not only as a digital learning medium, but also as a digital learning management instrument systematically designed using the Dick and Carey model in the context of junior high school biology learning. This research provides a theoretical contribution by expanding the study of educational technology that links instructional system design, digital learning management, and the development of critical thinking in an integrated manner. Practically, this research offers an implementation model that can be used as a reference for teachers, schools, and policymakers in managing technology-based science learning in a structured, data-driven manner, and oriented towards the development of 21st-century skills.

METHODS

Research Design

This study uses a Research and Development (R&D) approach with the main objective of producing and testing the effectiveness of a learning product in the form of a web-based digital learning management strategy through the integration of Nearpod in junior high school Biology learning. The R&D approach was chosen because it is not only oriented towards testing theory, but also on developing systematic, contextual, and applicable instructional solutions in real educational environments (Borg & Gall, 2003; Richey & Klein, 2007).

The development framework used is the Dick and Carey instructional design model, which views learning as an integrated system of objectives, materials, strategies, media, and evaluation (Dick et al., 2015). This model is relevant in the context of educational technology because it allows for the structured and sustainable integration of digital technology into learning management. In this study, the Dick and Carey model is used not only as an instructional design guide but also as a managerial framework for managing Nearpod-based digital learning. The development followed nine integrated stages:

1. Learning Needs Analysis (Identify Instructional Goals)

The initial stage was conducted to identify gaps between the current Biology learning environment and the desired ideal environment. A needs analysis was conducted through preliminary studies, classroom observations, interviews with Biology teachers, and analysis of curriculum documents. This stage aimed to determine the need for digital learning development that could enhance students' critical thinking skills (Branch, 2009; Morrison et al., 2019).

2. Conduct Instructional Analysis

Learning analysis was conducted to outline the basic competencies of junior high school biology, which require critical thinking skills, particularly in the aspects of analysis, evaluation, and inference. At this stage, researchers identified the cognitive skill steps that students must master to optimally achieve biology learning objectives (Gagné et al., 2005; Ennis, 2018).

3. Analyze Learners and Contexts

This stage aims to analyze the characteristics of eighth-grade students, including their initial biology skills, digital literacy levels, learning styles, and school infrastructure readiness. Context analysis is conducted to ensure that the digital learning design aligns with the actual conditions of the school environment and supports the effective implementation of Nearpod (Reigeluth, 2013; Selwyn, 2016).

4. Formulating Learning Objectives (Write Performance Objectives)

Based on the analysis of student needs and characteristics, learning objectives are formulated specifically, measurably, and oriented toward developing critical thinking in biology. The formulation of objectives refers to the principles of outcome-based education and

constructive alignment, so that objectives, activities, and evaluations are in a systemic alignment (Biggs & Tang, 2011).

5. Developing Assessment Instruments

An assessment instrument was developed to measure Biology students' critical thinking skills, encompassing indicators of analysis, evaluation, and inference. The instrument consisted of descriptive and reasoned-choice tests designed in accordance with Ennis and Facione's critical thinking framework. The instrument's content validity was assessed by experts, while its reliability was tested using the Cronbach's Alpha coefficient (Facione, 2015; Nitko & Brookhart, 2014).

Developing an Instructional Strategy: The learning strategy was designed by integrating Nearpod features, such as interactive slides, open-ended questions, collaborate boards, time to climb, and real-time quizzes. This strategy was designed to encourage active student engagement and facilitate higher-order thinking processes in Biology learning. This approach aligns with the principles of technology-enhanced learning and active learning in educational technology (Dede, 2018; Mayer, 2020).

Developing and Selecting Instructional Materials Biology learning materials are developed in the form of digital content on the Nearpod platform, including visualizations of biological processes, learning videos, interactive simulations, and formative questions. Material development takes into account the principles of multimedia learning so that students' cognitive load remains optimally managed (Mayer, 2020).

6. Formative Evaluation (Design and Conduct Formative Evaluation)

Formative evaluation is conducted through expert review, one-to-one trials, and small group trials. This stage aims to obtain feedback to improve the quality of the learning design and ensure the product's applicability before wider field implementation (Tessmer, 1993; Dick et al., 2015).

7. Revision and Field Implementation (Design and Conduct Summative Evaluation)

The final stage involved product revision based on the results of the formative evaluation and the implementation of Nearpod-based digital biology learning in the experimental class. The implementation aimed to test the effectiveness of digital learning management strategies in improving students' critical thinking skills.

Research Subjects and Ethical Considerations

The research subjects consisted of 72 eighth-grade junior high school students, three biology teachers, two instructional media experts, and one educational technology expert. Subjects were selected using a purposive sampling technique, considering their direct involvement in the development and implementation of digital learning (Creswell & Plano Clark, 2018). Regarding ethical considerations, the researchers obtained formal research clearance from the participating school's administration. Furthermore, informed parental consent was secured for all 72 student participants, ensuring they were aware of the data collection process and that their anonymity would be maintained throughout the publication.

Data Collection Technique

Research data was collected through several techniques, namely: (1) observation of Nearpod-based Biology learning to see the implementation of digital learning management strategies; (2) student and teacher response questionnaires to measure perceptions of the practicality and acceptability of the product; (3) Biology critical thinking ability tests in the form of pretests and posttests; (4) teacher interviews to obtain qualitative data related to the

managerial aspects of digital learning; and (5) documentation of Nearpod activities in the form of student-paced reports and class reports.

Data Analysis Techniques

Data analysis was conducted qualitatively and quantitatively. Qualitative data were analyzed through data reduction, data presentation, and drawing conclusions to describe the implementation and management of digital learning (Miles et al., 2014). Quantitative data were analyzed using N-Gain score calculations to assess improvements in critical thinking skills and learning effectiveness. Instrument validity and reliability were analyzed to ensure the accuracy of learning outcome measurements.

RESULTS AND DISCUSSION

Results

The implementation of the digital learning management strategy using the Dick and Carey model involved 72 eighth-grade students. The quantitative results indicate a significant improvement in students' critical thinking skills, with an average increase of 26.8% across three key domains. These findings are summarized in Table 1 below:

Table 1. Comparison of Students' Pre-test and Post-test Critical Thinking Scores

Indicator of Critical Thinking	Pre-test Mean	Post-test Mean	Gain (%)	N-Gain Score	Interpretation
Analysis	63.5	80.2	26.3%	0.46	Medium
Evaluation	61.2	78.5	28.3%	0.45	Medium
Inference	62.5	78.6	25.8%	0.43	Medium
Overall Average	62.4	79.1	26.8%	0.44	Medium-High

Observations of the learning process also showed that the Nearpod platform effectively recorded student engagement. Analytics from Nearpod's reports provided real-time data on student participation in interactive quizzes, collaborative boards, and open-ended responses, which served as the basis for formative assessment during the Biology lessons.

Discussion

The significant increase in students' critical thinking skills (26.8%) demonstrates that a systematically managed digital learning environment can optimize high-level cognitive activities. This finding aligns with the principles of constructive alignment, where the success of technology integration depends on the coherence between learning objectives, instructional strategies, and evaluation (Biggs & Tang, 2011; Ennis, 2018; Facione, 2015).

From an educational technology perspective, the results of this study reinforce the view that digital technology does not automatically improve the quality of learning. The positive impact of technology depends heavily on the quality of instructional design and accompanying learning management (Kirkwood & Price, 2014; Selwyn, 2016). Nearpod in this study was integrated through the analysis of needs, student characteristics, and the demands of the junior high school biology curriculum, ensuring its use is contextual and goal-oriented (Dick et al., 2015). This approach aligns with the view that learning technology will be effective when used strategically to support complex thinking processes and meaningful learning (Dede, 2018).

Observations and analysis of student activity data indicate that Nearpod functions beyond conventional learning media and serves as a digital learning management tool. This platform provides comprehensive support ranging from lesson planning and interactive learning implementation, real-time monitoring of the learning process, to data-driven evaluation through learning analytics (Ifenthaler & Yau, 2020; Viberg et al., 2018). Nearpod's automated

reporting feature allows Biology teachers to obtain a comprehensive overview of student engagement levels, conceptual understanding, and responses to each learning activity, as recommended in the technology-enhanced learning literature (Gašević et al., 2016; Siemens & Long, 2011). This allows for rapid, adaptive, and empirically evidence-based instructional decision-making.

This approach aligns with the concept of data-informed instruction in educational technology, which emphasizes the use of learning data to improve teaching quality and student learning outcomes (Mandinach & Gummer, 2016; Datnow & Park, 2019). In biology, data from students' responses to open-ended questions, formative quizzes, and collaborative activities provides teachers with important diagnostic information to identify misconceptions, adjust instructional strategies, and design appropriate follow-up actions (Black & Wiliam, 2009; Shute, 2008). This suggests that Nearpod contributes to improving the quality of digital classroom management, particularly in science subjects that require continuous, evidence-based monitoring of conceptual understanding (OECD, 2019).

The successful integration of Nearpod in this study is inseparable from the role of the Dick and Carey model as a learning system design framework. This model provides a systemic and structured approach to developing technology-based biology learning by placing objectives, strategies, and evaluations in a single system (Dick et al., 2015; Branch, 2009). The stages of needs analysis and student characteristics analysis ensure that the content, activities, and evaluations developed are relevant to the cognitive development level of junior high school students and aligned with the core competencies of the curriculum (Anderson & Krathwohl, 2001; Merrill, 2013). The integration of critical thinking assessment instruments from the design stage strengthens instructional coherence and the quality of learning assessments (Nitko & Brookhart, 2014; Brookhart, 2010).

This finding is consistent with the instructional systems design literature, which emphasizes that the effectiveness of digital learning is largely determined by the alignment between components of the learning system, not by technological sophistication alone (Reigeluth, 2013; Morrison et al., 2019; Richey et al., 2011). In the context of educational technology, the use of the Dick and Carey model helps Biology teachers transform from mere technology users to instructional designers capable of designing, managing, and evaluating digital learning reflectively and sustainably (Ertmer & Ottenbreit-Leftwich, 2013; Trust et al., 2017).

Despite the positive outcomes, this study identifies a critical limitation regarding the digital divide. The "Live Participation" feature of Nearpod, which was central to this management strategy, requires high-speed internet stability. In rural school settings with limited bandwidth, teachers may face challenges in maintaining the real-time monitoring flow. Future research should explore the adaptation of this strategy in "Student-Paced" modes to ensure that the benefits of digital learning management are accessible to students in varied technological contexts.

CONCLUSION

This study concludes that a digital learning management strategy through web-based Nearpod integration designed using the Dick and Carey model has proven effective in improving junior high school students' critical thinking skills in Biology learning. The 26.8% increase in critical thinking skills in the medium-high category indicates that systematically managed digital learning can optimize students' higher-level cognitive activities, particularly in the aspects of analysis, evaluation, and scientific inference. These findings confirm that the success of technology-based learning is not determined by the platform alone, but by the quality of the instructional design and accompanying learning management.

The integration of Nearpod in this study demonstrates a shift in the function of learning technology from simply a medium for delivering content to a digital learning management

system that supports integrated, data-driven learning planning, implementation, monitoring, and evaluation. The use of interactive features and learning analytics enables biology teachers to make adaptive, evidence-based instructional decisions, thereby sustainably improving the quality of science learning management.

The Dick and Carey model plays a significant role in ensuring alignment between learning objectives, learning strategies, learning activities, and evaluation. The systemic approach offered by this model helps maintain instructional coherence and constructive alignment in digital biology learning, while also strengthening the role of teachers as instructional designers capable of strategically, reflectively, and measurably managing learning technology.

Theoretically, this research enriches the study of educational technology by providing empirical evidence that the integration of instructional system design and digital learning platforms can significantly improve students' critical thinking skills in the context of science learning. Practically, the findings of this study provide implications for teachers, schools, and policymakers to develop and implement structured, data-driven digital learning management strategies oriented toward strengthening 21st-century competencies, particularly in Biology learning at the junior high school level.

CONFLICT OF INTEREST

No conflict of interest for this study.

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