

Mobile Learning Design and Its Role in Fostering Critical Thinking in Informatics Education

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Abstract

The use of mobile learning in vocational education continues to grow; however, its implementation often emphasizes technological development without sufficient attention to instructional organization and learning evaluation. This study aims to develop a Kodular-based mobile learning application and examine its practical feasibility and user acceptance in informatics learning. The research employed a research and development approach with exploratory evaluation, involving 20 vocational high school students selected through purposive sampling. Data were collected using user response questionnaires and learning indicator instruments to capture students' perceptions of usability, learning support, and cognitive engagement after using the application. The collected data were analyzed using descriptive percentage analysis to illustrate trends related to media feasibility and user acceptance. The results show that all evaluated aspects achieved percentages above 85%, indicating a very good level of practical feasibility and user acceptance, particularly in terms of usability, ease of use, and perceived learning support. These findings suggest that the developed mobile learning application can function as a supportive learning medium in vocational informatics education. This study provides practical insights into the development of mobile learning media that aligns instructional organization with learner needs in vocational learning contexts.

Keywords: critical thinking; learning outcomes; mobile learning; user acceptance test; vocational education

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INTRODUCTION

Recent advances in information and communication technology (ICT) has encouraged digital transformation in various aspects of life, including education (Harini et al., 2024). Modern information systems play an important role in improving organizational efficiency and facilitating faster and more effective information flow across business processes (Abdullahi & Mohamud, 2023). In the context of education, the integration of digital technology, particularly mobile learning, has significant potential to support more flexible and adaptive learning environments (Rangel-de Lazaro & Duarte, 2023). However, various studies show that the high level of adoption of learning technology has not been consistently followed by an improvement in the quality of students' cognitive achievements. According to the report of the Organisation for Economic Co-operation and Development (OECD) in 2025, states that the intensity of the use of digital technology in education does not automatically correlate positively with an



increase in learning outcomes (Wu, 2024). Lee & Lee (2024) also criticizes the normative view that assumes that technology itself is able to improve the quality of education without the support of proper pedagogical design. Liu & Zhang (2022) stated that the use of learning technology often only has an impact on the surface aspect of learning, while its contribution to the development of higher-order thinking skills is still limited.

This condition is also reflected in the Indonesian context, where the rapid growth of smartphone usage and digital applications has encouraged the public to increasingly access information and services through digital platforms (Kurniasih et al., 2024). The high penetration of digital technology shows that gadgets and the internet have become an inseparable part of students' lives. However, research by Agostini & Petrucco (2023) previous studies indicate that excessive smartphone use can negatively affect students' concentration and academic performance. This fact confirms the gap between the potential of digital technology as a means of learning and the realization of its impact on the quality of the learning process, especially in the development of high-level thinking skills.

Learning in schools is not only directed at achieving instructional goals, but also at developing higher-level thinking skills, especially critical thinking (Le et al., 2024; Lube et al., 2025). Along with the increasing use of mobile learning in learning practices, this technology is often positioned as a means to increase flexibility and access to learning. Ghoulam et al. (2024) show that the effectiveness of mobile learning is not solely determined by its adoption rate, but by how mobile learning-based learning design is able to facilitate students' cognitive processes in depth. However, empirical findings also indicate that most studies still view mobile learning primarily as a medium for material distribution. With an emphasis on improving low-level cognitive learning outcomes, such as comprehension and memory, while aspects of learning design that support high-level thinking processes have not been adequately explored (Skulmowski & Xu, 2022). As a result, there is a conceptual gap between the potential of mobile learning as an interactive and contextual learning environment and its contribution to the development of critical thinking as a key competency of the 21st century. This gap is scientifically important because without a mobile learning design that explicitly integrates analytical, reflective, and problem-based activities, the implementation of technology risks only producing a quantitative improvement in learning outcomes, without being accompanied by strengthening the quality of students' cognitive processes, especially in building critical thinking patterns.

Drawing on constructivist learning theory, effective learning environments are expected to actively engage learners in meaning-making processes through exploration, reflection, and problem solving, which are foundational to the development of critical thinking skills. From this theoretical perspective, mobile learning should not be understood merely as a content delivery medium, but as an instructional design that structures cognitive activities enabling learners to analyze, evaluate, and apply knowledge in authentic contexts (Okai et al., 2022). However, recent literature indicates that many mobile learning studies still lack strong theoretical grounding that explicitly links instructional design features to critical thinking processes and subsequent learning outcomes. Galimova et al. (2025) It states that existing research often measures critical thinking skills and learning outcomes as separate variables, without explaining how specific mobile learning design elements operationalize constructivist principles to support higher-order thinking. Consequently, there remains limited understanding of why and how mobile learning designs facilitate critical thinking, particularly in informatics education where abstract concepts and systematic problem-solving skills are central (Pedraja-rejas et al., 2024).

This study focuses on the development of a Kodular-based mobile learning application using the ADDIE learning model and examines its impact on critical thinking skills and student learning outcomes. This study makes a theoretical contribution by clarifying how mobile

learning design functions as a cognitive framework that supports analytical, reflective, and problem-oriented thinking processes. Methodologically, this study integrates systematic instructional design with empirical evaluation by incorporating critical thinking assessment and learning outcome measurement. Contextually, these findings offer empirical evidence from vocational informatics education, highlighting the role of well-designed mobile learning environments in supporting higher-order thinking skills.

METHOD

This study employed a Research and Development (R&D) approach using the learning design model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (ADDIE) to develop a Kodular-based mobile learning application for Basic Informatics instruction at SMK Negeri 2 Situbondo. The ADDIE model was selected because it provides a systematic yet flexible framework for designing and refining instructional media through iterative stages, ensuring alignment between learning objectives, instructional activities, and evaluation processes (Kamilah, 2026). During the analysis stage, learning needs, curriculum requirements, and student characteristics were identified. The design stage translated these needs into learning structures, interface layouts, navigation flows, and assessment components. The development stage involved building the mobile application using Kodular, integrating instructional materials, interactive elements, and evaluation features. The implementation stage consisted of pilot use in one class involving 20 students selected purposively, representing users within the intended instructional context. Continuous formative revisions were conducted across stages based on feedback and observed usability issues.

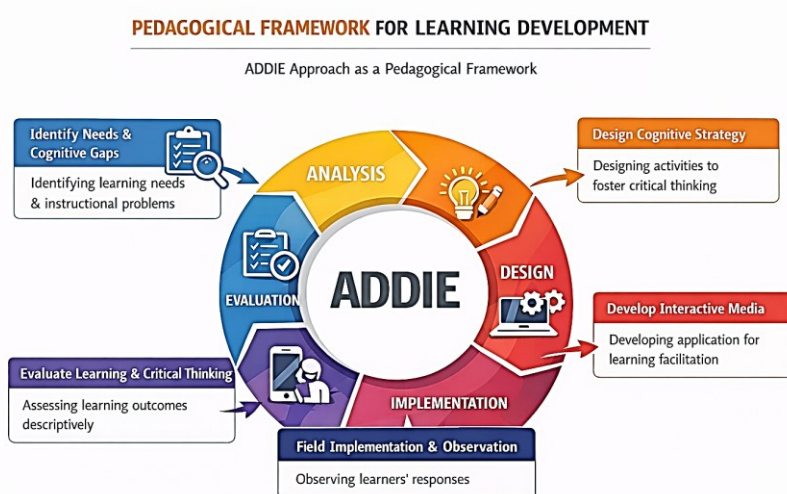


Figure 1. Pedagogical framework learning development

Figure 1 illustrates the pedagogical framework of the learning media development process using the ADDIE model. The figure shows the sequential yet iterative nature of the five stages, emphasizing how analysis informs design decisions, design guides development, development leads to implementation, and evaluation provides feedback for continuous refinement. This framework ensures that the developed mobile learning application is pedagogically grounded and aligned with instructional objectives.

Evaluation focused on determining product feasibility, usability, and pedagogical potential rather than testing causal learning effects. User evaluation employed a User Acceptance Test (UAT) to measure user satisfaction, usability, and alignment with learning

needs after direct application use. UAT was conducted using a Likert-scale questionnaire completed by end users to evaluate system acceptability and ensure that the developed system meets user requirements, as user acceptance and usability are commonly assessed using questionnaire based instruments (Hajesmaeel-Gohari et al., 2022). In addition, student perceptions of cognitive engagement during learning were collected using a questionnaire derived from five indicators: problem analysis, information evaluation, reasoning, drawing conclusions, and decision-making, reflecting the logical reasoning and problem-solving skills required in informatics learning.

Learning outcomes were examined through comprehension tests to provide an indicative view of student’s cognitive achievement after using the application. Data were analyzed descriptively using percentage conversion of questionnaire scores by dividing obtained scores by maximum scores and multiplying by 100 to obtain feasibility and acceptance levels. Results were then categorized into quality levels to facilitate interpretation. This descriptive approach was chosen to evaluate usability and instructional potential rather than conduct inferential testing, allowing the findings to describe trends related to media feasibility and user acceptance within the pilot context.

Table 1. Data analysis framework of the study

No.	Data Type	Instrument	Analysis Technique	Analysis Output
1	Media use evaluation	User response questionnaire	Descriptive percentage analysis	Category of media use quality
2	User acceptance	User UAT questionnaire	Descriptive percentage analysis	Level of user acceptance
3	Learning indicators/ critical thinking	Student questionnaire	Descriptive percentage analysis	Indicative trends of learning indicators

RESULTS AND DISCUSSION

Result

The analysis phase was conducted to identify students’ learning needs, curriculum requirements, and user characteristics. The analysis of each data source highlighted that students required an interactive and flexible learning medium to support independent learning in basic informatics. In addition, curriculum analysis emphasized the importance of aligning the learning content with instructional objectives. These findings served as the foundation for developing the KoduLearn application.

Based on the analysis results, the design phase focused on developing a structured learning flow, interface layout, and application features. This led to the generation of a design that was in accordance with Basic Informatics instructional objectives. The design was tailored to support learning by integrating learning materials, quizzes, and user-friendly navigation. The overall design aimed to create an engaging and organized learning environment that facilitates student interaction and understanding.

The mobile learning application KoduLearn that integrates the learning content, discovery features and engaging elements was developed based on the design process. In accordance with the ADDIE model's development phase, the KoduLearn application underwent a validation process prior to field implementation. The validation aimed to evaluate the media usability and instructional content feasibility.

As shown in Table 2, the overall validation achieved an average score of 90%, categorizing the media as "Very Feasible". Feedback from the validators, such as adjusting button sizes and refining question clarity, was accommodated to improve the application before user testing. These improvements indicate that the application has met the required standards

in terms of usability and instructional quality, making it suitable for implementation in the Implementation phase.

Table 2. Media validation results

Validator	Evaluated Aspect	Percentage (%)	Category
Media Expert	Interface design and navigation	89%	Very Feasible
Media Expert	Technical functionality	91%	Very Feasible
Subject Matter Expert	Content relevance and accuracy	92%	Very Feasible
Subject Matter Expert	Pedagogical structure	88%	Very Feasible
Average		90%	Very Feasible

The validated application was then implemented in a learning environment. The system was designed to support learning activities through structured menus and interactive features. The interface emphasizes pedagogical effectiveness while minimizing cognitive overload. To illustrate the core functionality of KoduLearn, the main interfaces supporting the learning process are presented below.

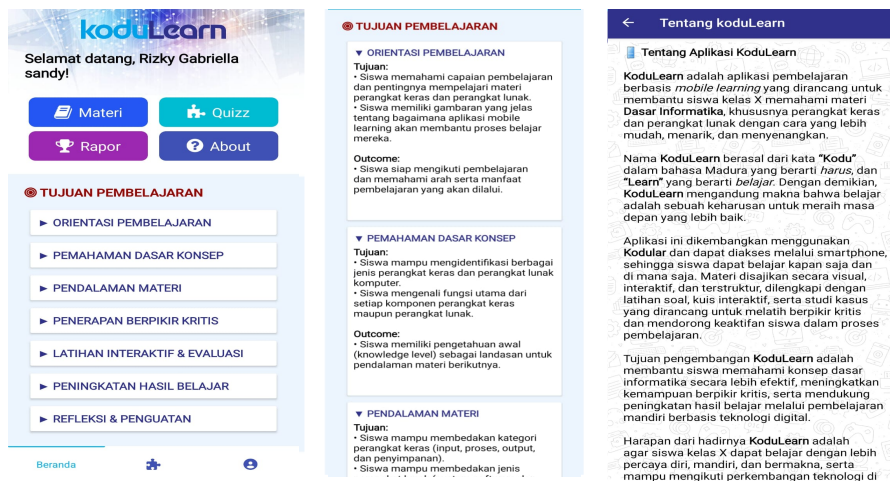


Figure 2. Home main menu

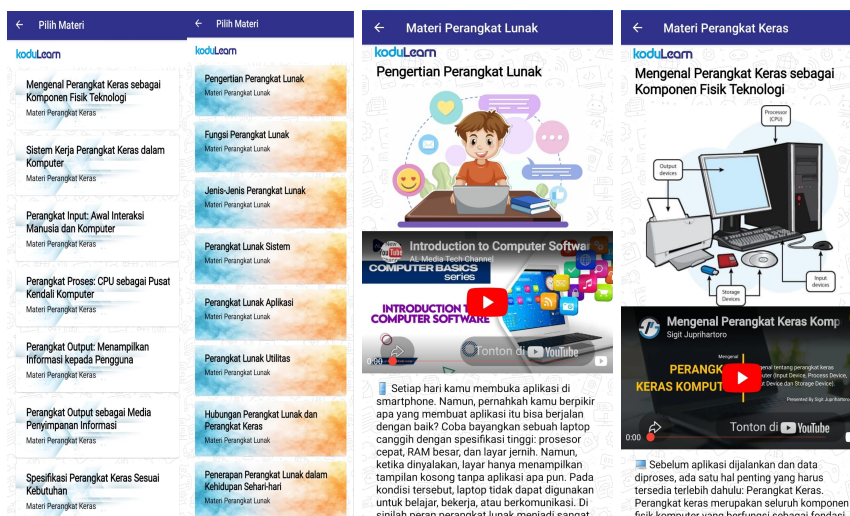


Figure 3. Learning material features

The main menu interface of the KoduLearn application can be observed in Figure 2, showcasing several core features, including learning materials, quizzes, report cards, and an information section. These features are deliberately structured to support intuitive navigation, allowing users to access various learning resources and functionalities directly from the homepage. The interface design emphasizes clarity and organization in presenting the learning components.

Meanwhile, the learning material feature is depicted in Figure 3, where the content is arranged into structured topics and subtopics related to fundamental informatics concepts. Each topic is presented through textual explanations supported by images and instructional videos, enabling learners to engage with the material in a sequential manner. The overall design of the material presentation is intended to encourage independent exploration and strengthen conceptual understanding.

The quiz functionality within the KoduLearn application, as depicted in Figure 4, provides multiple-choice questions aligned with selected learning topics. Before beginning the activity, users can select their preferred quiz category, and upon completion, the system displays the results along with immediate feedback on each response. This feature serves as an integral component for practice and evaluation, supporting the development of critical thinking skills and encouraging reflective learning within the educational environment.

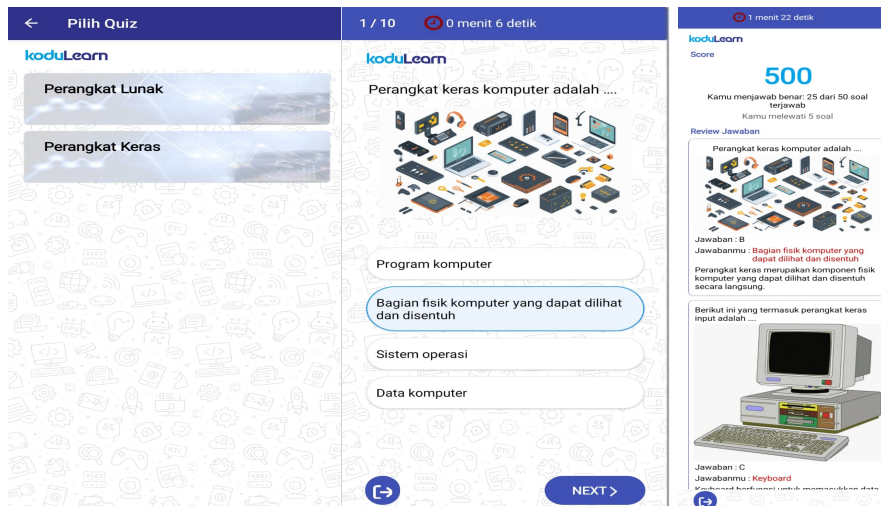


Figure 4. Quiz features

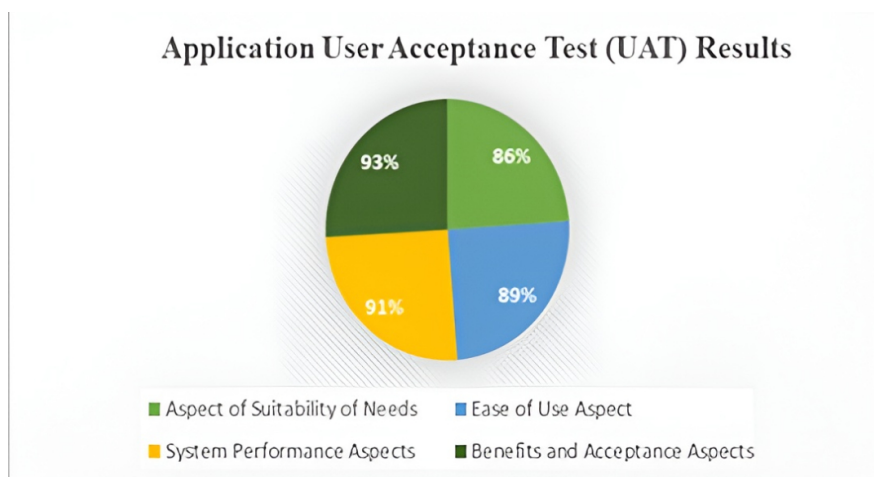


Figure 5. User acceptance test results

The validation and implementation phase, students were tasked with evaluating the app for functionality, usability and fit within the learning context. The feasibility of the KoduLearn application was evaluated based on students' responses after using the application, using the UAT approach. The evaluation focused on usability, system performance, ease of use, and suitability for learning needs.

Based on the UAT diagram, all aspects of the assessment obtained a percentage (Figure 5) 85%, which shows that the developed application is in the category of excellent and acceptable to users. The Benefits and Acceptance aspect obtained the highest percentage of 93%, which shows that the application is considered to provide clear benefits and can be well received by users. The System Performance aspect obtained a percentage of 91%, which indicates that the system performance is running well and is able to support user activities optimally. Furthermore, the Ease-of-Use aspect gained a percentage of 89%, which shows that the app is easy to use and understand by users. Meanwhile, the Suitability of Needs aspect obtained a percentage of 86%, which remains in the very good category, despite being the aspect with the lowest percentage.

In alignment with the pedagogical evaluation phase of the ADDIE framework, students' perceptions of cognitive engagement were systematically assessed using a questionnaire comprising five critical thinking indicators relevant to informatics learning. The corresponding trends in these learning outcomes are presented in Table 3. The findings demonstrate consistently positive results across all indicators, indicating that the implementation of the KoduLearn application effectively facilitates and strengthens students' cognitive engagement within the learning process.

Table 3. Critical thinking indicators results

No.	Critical Thinking Indicator	Percentage (%)	Category / Trend
1	Problem analysis	88%	Very Good
2	Information evaluation	87%	Very Good
3	Reasoning	89%	Very Good
4	Drawing conclusions	85%	Very Good
5	Decision-making	86%	Very Good
	Average Score	87%	Very Good

Furthermore, student perceptions of critical thinking were measured using a questionnaire consisting of five indicators. The results, as presented in Table 3, show that all indicators demonstrated positive trends, with an overall average score of 87%, categorized as "Very Good". This indicates that the use of KoduLearn supports students' cognitive engagement in learning.

In more detail, the highest achievement was observed in the reasoning indicator at 89%, suggesting that the interactive features effectively stimulated students' logical thinking skills. Meanwhile, the drawing conclusions indicator obtained the lowest score at 85%, which, although still within a positive category, highlights an area for further instructional improvement.

Discussions

The results indicate that the KoduLearn application is feasible as a mobile learning medium and receives positive responses from users. These findings can be interpreted through the development stages applied in this study. Prior to user testing, the application's foundational quality was established through expert validation using the media use evaluation instrument. The high feasibility rating based on user evaluation is influenced by the structured presentation of learning materials aligned with curriculum objectives. The content organization from

orientation to conceptual understanding allows students to follow a gradual learning progression. Such structured sequencing helps learners build conceptual understanding step by step, particularly in informatics learning where abstract concepts must be connected with practical examples. Previous studies have also shown that mobile learning media with structured instructional flow significantly improve learning clarity and student engagement because learners can access materials according to their learning pace and needs (Chisunum & Nwadiokwu, 2024). Therefore, the results of user-based evaluation indicating high material suitability reflect the effectiveness of systematic instructional organization within the application.

User acceptance results ($\geq 85\%$) are consistent with the TAM, particularly in terms of perceived usefulness and ease of use. Prior studies confirm that usability and system simplicity are key determinants of technology adoption (Lun et al., 2024). However, the findings of this study suggest a more nuanced interpretation: acceptance is not solely driven by usability, but also by the perceived cognitive value of the application. This aligns with research indicating that technology adoption in education is strengthened when digital tools meaningfully support learning processes rather than merely providing access (Lee & Lee, 2024).

The positive trends across critical thinking indicators (average 87%) indicate that KoduLearn functions as a cognitive learning environment rather than a passive content delivery tool. Interactive elements, particularly quizzes with immediate feedback, appear to support reasoning and metacognitive regulation. This is consistent with findings that formative feedback enhances cognitive engagement and supports deeper learning processes (Solis Trujillo et al., 2025). However, the relatively lower performance in drawing conclusions suggests that the current design is more effective in supporting analytical processes than higher-order synthesis. This limitation aligns with prior studies showing that digital learning environments often struggle to facilitate advanced thinking skills unless they incorporate inquiry-based or problem-based activities (Liu & Zhang, 2022).

This study contributes to the literature by identifying instructional design features structured sequencing, interactivity, and feedback as key mechanisms that mediate the relationship between mobile learning and cognitive engagement. Previous research has often treated critical thinking as an outcome variable without clearly explaining the underlying processes (Galimova et al., 2025). By highlighting these mediating mechanisms, this study shifts the focus from whether mobile learning is effective to how it supports higher-order thinking.

Several limitations must be acknowledged. The use of descriptive analysis and self-reported measures limits causal inference and may introduce response bias. In addition, the small sample size and single-context implementation restrict the generalizability of the findings. These limitations are consistent with challenges identified in prior educational technology research (Lu et al., 2022).

Therefore, future research should employ experimental or quasi-experimental designs and incorporate performance-based assessments to more rigorously evaluate the impact of mobile learning on critical thinking. The effectiveness of mobile learning is determined not by technological sophistication alone, but by the integration of pedagogical structure, cognitive support, and usability. These findings reinforce the need for cognitively intentional instructional design to ensure that mobile learning environments can meaningfully support higher-order thinking skills.

CONCLUSION

This study developed a Kodular-based mobile learning application, KoduLearn, to This study confirms that the KoduLearn mobile learning application is both feasible and positively received by users, with promising indications for enhancing students' critical thinking in

informatics education. The results emphasize that the success of mobile learning is driven not merely by the presence of technology, but by the effective integration of instructional structure, interactivity, and feedback that facilitate cognitive engagement. This study contributes by demonstrating that these design elements function as key mechanisms linking mobile learning to higher-order thinking, thereby repositioning mobile learning as a cognitively oriented learning environment rather than a simple content delivery medium. Nevertheless, the findings should be interpreted cautiously due to the study's descriptive design, limited sample size, and reliance on self-reported data, which limit generalizability and causal claims. Future research is therefore recommended to adopt more rigorous experimental methods, incorporate performance-based measures, and integrate inquiry-driven learning activities to further strengthen the development of higher-order cognitive skills.

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