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Developing an AI-Based Digital Literacy Application to Support Indonesian Language Learning Aligned with the Merdeka Curriculum

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ABSTRACT

The integration of artificial intelligence (AI) in language learning offers opportunities to support digital literacy, personalized feedback, and interactive learning. This study aimed to develop and preliminarily evaluate Lithascyai, an AI-based digital literacy application prototype designed to support Indonesian language learning in alignment with the Merdeka Curriculum. This study employed a research and development design using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation stages. The prototype was developed as a web-based application integrating Indonesian language learning materials, AI-assisted writing support, text analysis, language correction, adaptive feedback, and digital literacy activities. A limited classroom trial was conducted involving a control class using conventional learning materials and an experimental class using the AI-based application. Data were collected through product development documentation and pre-test and post-test scores. Learning improvement was analyzed descriptively using normalized gain. The study produced an AI-based digital literacy application prototype that provides learning materials, writing assistance, text analysis, language correction, and digital literacy support. The experimental class showed higher learning improvement than the control class. Assuming a maximum score of 100, the normalized gain was 0.59 for the control class and 0.74 for the experimental class, indicating greater improvement among students who used the application. The findings suggest that Lithascyai has potential as a digital learning medium for supporting Indonesian language learning. However, broader trials, expert validation, user response analysis, and statistical testing are needed to confirm its effectiveness, usability, and ethical implementation.

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1. INTRODUCTION

The rapid development of digital technology has transformed the ways students access information, construct knowledge, and communicate in academic contexts. In language education, this transformation requires learners not only to master linguistic competence but also to develop digital literacy skills that

enable them to search, evaluate, interpret, and produce information responsibly. Digital literacy is increasingly viewed as a multidimensional competence that includes technical, cognitive, communicative, and ethical dimensions of technology use (Falloon, 2020; Law et al., 2018). For Indonesian language learning, digital literacy is particularly important because students are expected to read critically, write effectively, evaluate digital texts, and communicate ideas in various forms of media.

Despite the growing importance of digital literacy, Indonesian language learning still faces several challenges. Conventional learning practices often rely on printed materials, teacher-centered explanation, and delayed feedback, which may limit students' opportunities to revise their writing, practice independently, and engage with interactive learning resources. In addition, many students still need support in evaluating digital information, identifying credible sources, avoiding misinformation, and using technology ethically in academic tasks (Breakstone et al., 2018; Sari et al., 2020). These challenges indicate the need for learning media that can support both language proficiency and digital literacy in an integrated manner.

The implementation of the Merdeka Curriculum further strengthens the need for flexible, student-centered, and technology-supported learning. The curriculum encourages differentiated instruction, meaningful learning experiences, and the development of competencies relevant to twenty-first-century education. In this context, digital learning media can help teachers and lecturers provide more adaptive materials, promote learner autonomy, and create learning activities that are more responsive to students' needs. However, the effective use of digital media requires careful instructional design so that technology is not used merely as a tool for presentation but as a means to support learning processes, feedback, and skill development (McDougall et al., 2018; Pratolo & Solikhati, 2020).

Artificial intelligence has recently gained attention in education because of its potential to provide personalized learning, immediate feedback, automated text analysis, and adaptive recommendations. AI-supported learning tools can assist students in identifying language errors, improving writing quality, receiving suggestions, and practicing language skills more independently. Previous studies have shown that AI literacy and AI-supported learning environments may enhance students' engagement and help them develop competencies needed in digital society (Almatrafi et al., 2024; Ng et al., 2024). Nevertheless, the integration of AI into education should be accompanied by pedagogical, ethical, and technical considerations, including the accuracy of feedback, data privacy, transparency of system functions, and alignment with learning objectives.

Although many studies have discussed digital literacy and AI in education, research on the development of AI-based applications specifically designed to support Indonesian language learning remains limited. Existing studies tend to focus on general digital literacy, teacher readiness, or the use of technology in broader educational contexts. There is still a need for research that develops a prototype application aligned with Indonesian language learning needs and evaluates its potential use in classroom instruction. This gap is important because Indonesian language learning requires not only grammar and vocabulary support but also assistance in reading comprehension, writing development, text evaluation, and responsible digital communication.

To address this need, the present study develops an AI-based digital literacy application prototype called Lithascyai, designed to support Indonesian language learning. The prototype integrates features such as AI-assisted writing support, text analysis, language correction, learning materials, and digital literacy activities. These features are intended to help students improve their understanding of Indonesian language materials while also strengthening their ability to use digital tools critically and productively. The application is also designed to support learning activities that are more interactive, adaptive, and aligned with the principles of the Merdeka Curriculum.

This study is positioned as research and development that focuses on the design, development, and preliminary evaluation of the prototype. Specifically, the study aims to describe the development process of the AI-based digital literacy application, examine its feasibility as a learning medium, and investigate its preliminary effect on students' Indonesian language learning outcomes. By developing and evaluating this prototype, the study is expected to contribute to the field of educational technology, particularly in

the integration of AI, digital literacy, and Indonesian language learning. The findings may also provide practical insights for lecturers, teachers, and institutions seeking to implement technology-supported learning in accordance with contemporary curriculum demands.

2. METHODS

2.1 Research Design

This study employed a research and development (R&D) design to develop and conduct a preliminary evaluation of an AI-based digital literacy application prototype for Indonesian language learning. The development procedure was adapted from the ADDIE model, which consists of five main stages: analysis, design, development, implementation, and evaluation (Branch, 2009). This model was selected because it provides a systematic framework for designing, producing, validating, and revising technology-based learning media.

The study focused on two main purposes. First, it aimed to develop an AI-based digital literacy application prototype called Lithascyai to support Indonesian language learning. Second, it aimed to examine the feasibility of the prototype and its preliminary effect on students' learning outcomes. Therefore, the study combined product development procedures with a limited classroom trial using a pre-test and post-test design. The following figure describes the stage in ADDIE:

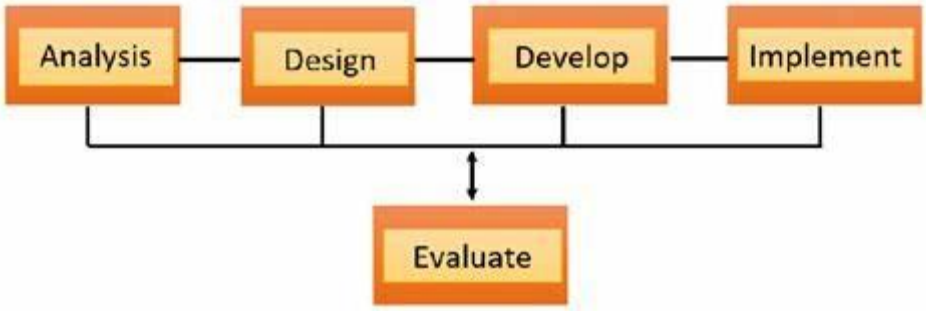

Figure 1. Research and Development Procedure Using the ADDIE Model

2.2 Research Setting and Participants

The study was conducted at the Faculty of Teacher Training and Education, University of HKBP Nommensen Pematangsiantar, Indonesia. The participants were students enrolled in the Indonesian language learning course in the Elementary School Teacher Education Program. Two classes were involved in the preliminary implementation stage: one control class and one experimental class. The control class learned using conventional teaching materials or student handbooks, while the experimental class learned using the AI-based digital literacy application prototype.

The participants were selected using purposive sampling because they were considered relevant to the purpose of the study, namely, prospective elementary school teachers who needed to strengthen their Indonesian language competence and digital literacy skills. The total number of participants was 62, consisting of 32 students in the control class and 30 students in the experimental class. In addition, the validation stage involved 1 material expert, 1 media or educational technology expert, and 1 user representative to assess the feasibility of the prototype.

2.3 Development Procedure

The development process followed the five stages of the ADDIE model. The first stage was analysis. At this stage, the researchers identified learning needs, curriculum requirements, and user expectations related to Indonesian language learning and digital literacy. Data were collected through literature review, observation of learning practices, and questionnaires or interviews with students and lecturers. The needs analysis focused on students' difficulties in Indonesian language learning, the need for digital literacy support, and the types of application features considered useful for learning.

The second stage was design. Based on the needs analysis, the researchers designed the application structure, learning flow, user interface, and main features of the prototype. The design included learning materials aligned with Indonesian language learning objectives, digital literacy activities, AI-assisted writing support, text analysis, language correction, adaptive feedback, and user guidance. At this stage, the researchers also prepared the research instruments, including expert validation sheets, user response questionnaires, and learning outcome tests.

The third stage was development. In this stage, the application prototype was developed based on the design specifications. The prototype, named Lithascyai, was designed as a web-based application that provides Indonesian language learning materials and AI-supported literacy features. The prototype included several main functions, such as language learning modules, writing assistance, text analysis, language correction, feedback provision, and digital literacy learning activities. After the initial prototype was completed, internal testing was conducted to check navigation, feature functionality, display quality, and technical performance.

The fourth stage was implementation. The prototype was implemented in a limited classroom trial. Before the treatment, both the control and experimental classes were given a pre-test to identify their initial learning achievement. The control class was taught using conventional learning resources, while the experimental class used the AI-based digital literacy application during the learning process. After the learning intervention, both classes were given a post-test to measure changes in learning outcomes.

The fifth stage was evaluation. Evaluation was conducted through expert validation, user responses, and learning outcome analysis. Feedback from validators and users was used to revise the prototype. The evaluation focused on content suitability, media design, ease of use, technical functionality, language clarity, curriculum alignment, and the potential of the application to support Indonesian language learning.

2.4 Research Instruments

Several instruments were used in this study. First, a needs analysis questionnaire was used to identify students' learning needs, digital literacy challenges, and expectations for technology-supported learning. Second, expert validation sheets were used to assess the feasibility of the application. The validation covered content quality, alignment with learning objectives, media design, navigation, usability, language accuracy, and technical performance. Third, a learning outcome test was used to measure students' achievement before and after the intervention. The test consisted of items related to Indonesian language learning materials. Fourth, a user response questionnaire was used to collect students' perceptions of the application's usability, attractiveness, usefulness, and learning support.

Before being used, the instruments were reviewed by experts to ensure content validity. The reliability of the questionnaire and test instruments was examined using Cronbach's alpha. Items that did not meet validity or reliability criteria were revised or removed.

2.5 Data Collection Procedure

Data collection was carried out in several steps. First, the researchers conducted a needs analysis through questionnaires, interviews, and literature review. Second, the application prototype was designed and developed based on the needs analysis results. Third, the prototype was validated by experts in Indonesian language learning, educational technology, and learning media. Fourth, revisions were made based on expert feedback. Fifth, the revised prototype was implemented in the experimental class, while the control class used conventional learning materials. Finally, pre-test and post-test scores, user responses, and validator feedback were collected and analyzed.

2.6 Data Analysis

The data were analyzed using quantitative and descriptive techniques. Expert validation data were analyzed using percentage scores to determine the feasibility level of the application. The percentage was calculated by dividing the obtained score by the maximum possible score and multiplying the result by

100%. The feasibility results were then interpreted using predetermined criteria, such as very feasible, feasible, less feasible, or not feasible.

Students' learning outcomes were analyzed using pre-test and post-test scores. The improvement in learning outcomes was calculated using normalized gain, or N-gain, with the following formula:

N-gain = (post-test score − pre-test score) / (maximum score − pre-test score)

The N-gain score was interpreted using commonly used categories: high, moderate, or low improvement (Hake, 1998). To compare the learning outcomes of the control and experimental classes, the researchers also conducted an independent samples t-test or a Mann–Whitney U test, depending on the results of normality and homogeneity testing. User response data were analyzed descriptively to determine students' perceptions of the application.

2.7 Ethical Considerations

This study was conducted by considering research ethics. Participants were informed about the purpose of the study, the learning activities involved, and the use of the collected data for research purposes. Participation was voluntary, and the confidentiality of participants' identities was maintained. Because the study involved the use of an AI-based digital application, attention was also given to data privacy. User data were used only for research and learning evaluation purposes and were not shared with unauthorized parties. The researchers also ensured that the AI-generated feedback was used as learning support rather than as the sole source of academic judgment.

3. FINDINGS AND DISCUSSION

3.1 Findings

3.1.1 Development Output of the AI-Based Digital Literacy Application

The main output of this research was an AI-based digital literacy application prototype named Lithascyai or AI-Based Nancy Language Literacy. The prototype was developed as a web-based learning application designed to support Indonesian language learning and digital literacy development. The application can be accessed through the website address provided in the development process and was designed to assist users in learning Indonesian language materials, improving writing quality, and developing digital literacy skills.

The prototype consists of several main features. First, the application provides Indonesian language learning materials that are aligned with the learning objectives used in the course. These materials are intended to help students understand language concepts, grammar, vocabulary, and effective communication. Second, the application includes an AI-assisted writing feature that allows users to compose sentences, paragraphs, and longer texts with learning support. Third, the text analysis feature enables users to input written texts and receive feedback related to language structure, style, diction, and clarity. Fourth, the digital literacy feature provides learning activities related to ethical technology use, understanding digital information, and responsible communication in digital environments.

The development of these features indicates that the prototype was not designed only as a digital repository of learning materials but also as an interactive learning medium. Through AI-supported feedback, language correction, and learning activities, the application is expected to support students in practicing Indonesian language skills more independently. However, the technical accuracy of AI-generated feedback still requires further validation through expert review and broader user testing.

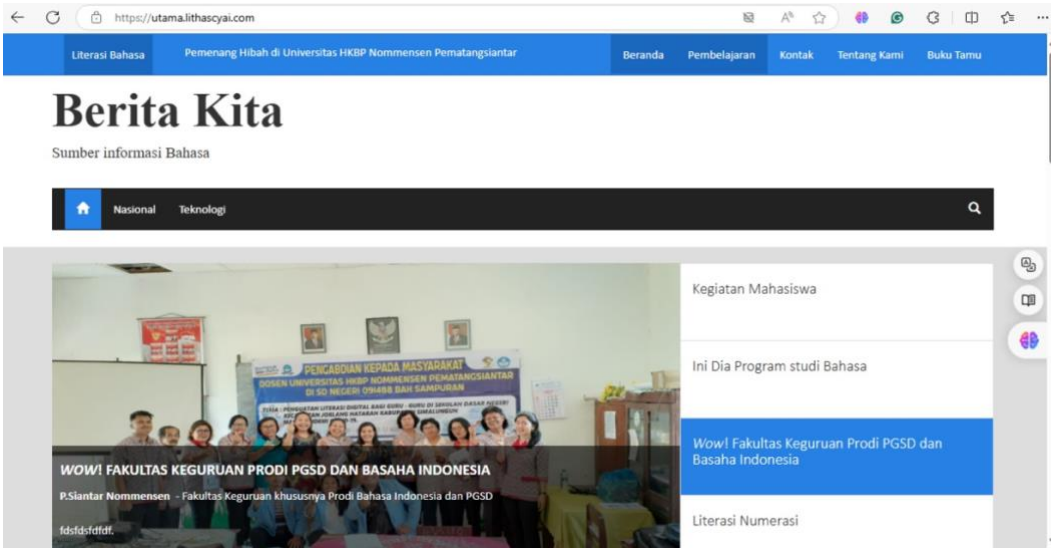

Figure 2. Home Page Design Document
Source: https://utama.lithascyai.com/

This feature allows the app to provide appropriate feedback, including grammar corrections, diction suggestions, and tips to improve writing quality. Digital Literacy Development: In addition to language, this app also trains users in understanding, researching, and interpreting digital information properly. Lithascyai has digital literacy modules that focus on ethical internet use, understanding fake news, and information security.

Lithascyai uses AI technology to maximize learning effectiveness. Here are some of its top features: AI Writing Assistant: Similar to a personal assistant, Lithascyai can help users craft effective sentences, paragraphs, and even articles as needed (Fathullah, Ulfiah, Mulyanto, Gaffar, & Khori, 2023). Multi-level Language Corrector: The app has a corrector that can adjust to the literacy level of the user, whether a beginner or a professional. Lithascyai provides language corrections that match the user's level needs (Maina & Rosemary, 2019).

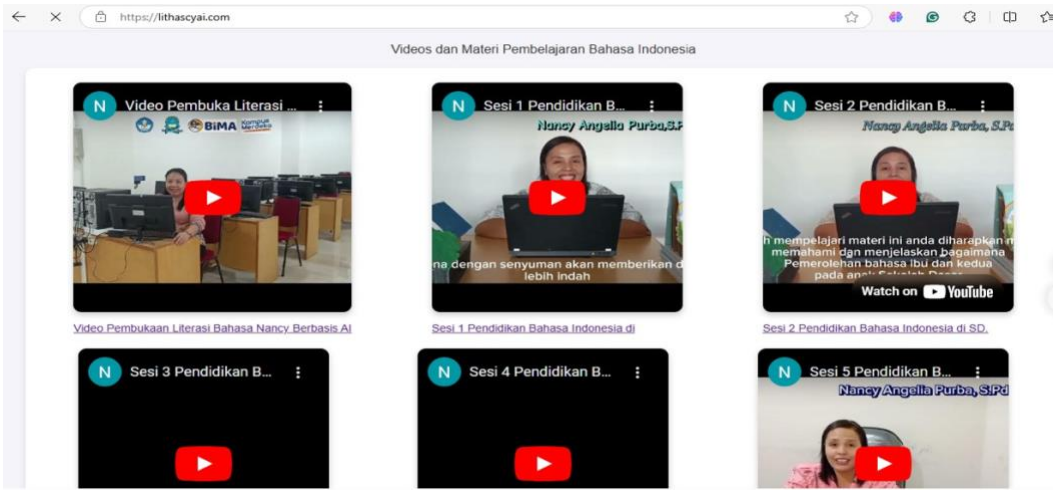

Figure 3. Testing Documents (Functional and Performance)
Source: https://lithascyai.com/

Lithascyai provides a language and writing style customization feature that enables users to adjust their writing according to different communication contexts, such as casual, formal, or creative styles. This feature allows users to practice producing texts that are appropriate for specific purposes and audiences. In addition, the application supports contextualized and interactive learning by integrating gamification elements, including challenges, scores, and trackable progress. These elements

are designed to make Indonesian language learning more engaging and enjoyable while encouraging users to monitor their learning development.

The use of Lithascyai also offers several potential benefits for language and digital literacy development. Through its language learning features, users can expand their understanding of both colloquial and formal language use. The availability of auto-correction and AI-assisted writing support helps users revise their writing more efficiently and understand learning materials without relying entirely on external assistance. In this way, the application may support more independent and practical learning. Furthermore, Lithascyai has the potential to promote inclusive education because it provides accessible literacy support for users with different levels of language ability and learning needs.

Lithascyai works by processing user input and feedback to provide relevant language support. The AI system is designed to recognize language patterns, identify possible errors, and generate suggestions based on the context of the text submitted by users. Through this process, the application can assist users in improving grammar, diction, writing structure, and clarity. Overall, the prototype demonstrates an innovative approach to supporting language literacy learning for academic, professional, and everyday communication purposes.

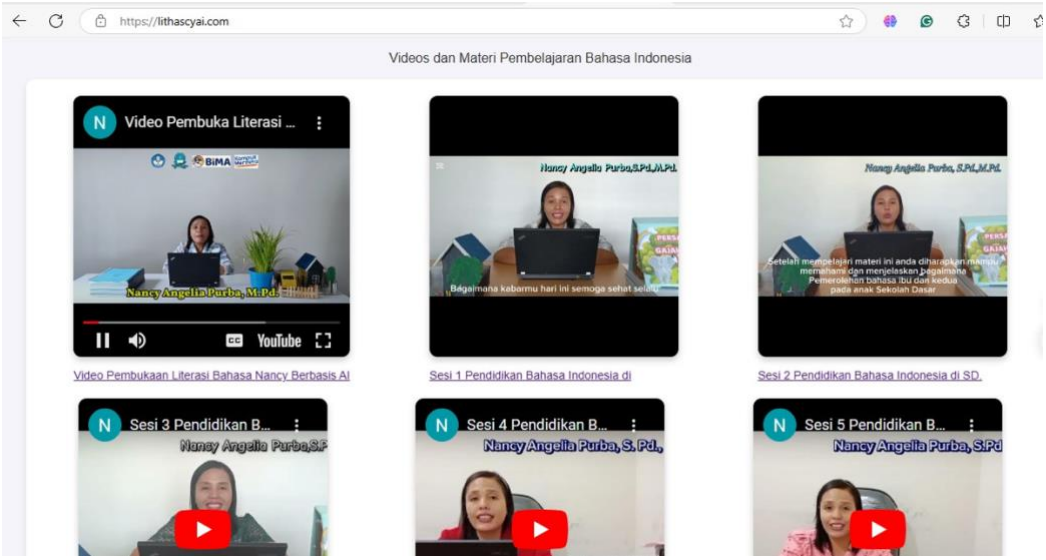

Figure 4. Development Process and Prototype Results of Lithascyai

Source: https://lithascyai.com/

3.1.2 Learning Materials and User Guidance

The learning materials integrated into the prototype focused on Indonesian language education, particularly materials relevant to elementary school teacher education. These materials were organized based on the learning plan used in classroom activities. The application was also supported by training and usage guidance to help students understand how to access the platform, use the available features, complete learning activities, and interpret the feedback provided by the system.

The presence of user guidance is an important part of the prototype because students may have different levels of digital literacy and familiarity with AI-based learning tools. Therefore, training during classroom implementation was used to introduce students to the application features and to reduce possible technical difficulties during the learning process.

3.1.3 Preliminary Implementation in Indonesian Language Learning

The prototype was implemented in a limited classroom trial involving two classes: a control class and an experimental class. The control class learned using conventional teaching materials, while the experimental class used the AI-based digital literacy application prototype during the learning process.

Before the learning intervention, both classes were given a pre-test to identify their initial learning achievement. After the intervention, both classes completed a post-test to identify changes in learning outcomes.

The descriptive results showed that both classes experienced improvement from pre-test to post-test. In the control class, the mean score increased from 18 ± 5.70 in the pre-test to 66 ± 8.21 in the post-test. In the experimental class, the mean score increased from 28 ± 5.70 in the pre-test to 81 ± 6.51 in the post-test. These results indicate that students in both classes showed better learning outcomes after the instructional process.

However, the experimental class obtained a higher post-test mean score than the control class. This suggests that the use of the AI-based digital literacy application may have contributed positively to students' Indonesian language learning outcomes. The difference may be related to the availability of interactive learning materials, AI-assisted feedback, and opportunities for students to revise and improve their understanding during the learning process.

Table 1. Data on Indonesian Language Learning Outcomes in Control and Experiment Classes

Class	Learning Outcomes	
	Pre test	**Post test**
Control	18 ± 5.70	66 ± 8.21
Experiment	28 ± 5.70	81 ± 6.51

3.1.4 Normalized Gain of Learning Outcomes

To identify the level of improvement in students' learning outcomes, the normalized gain, or N-gain, was calculated using the students' pre-test and post-test scores. The calculation of the normalized gain uses the following formula for the Control and Experimental Classes.

$$\text{N} - \text{gain} = \frac{Score\ postest - score\ pretest}{Score\ maksimum - score\ pretest}$$

Assuming that the maximum possible score was 100, the N-gain score for the control class was calculated as follows:

N-gain = (66 − 18) / (100 − 18) = 48 / 82 = 0.59

Meanwhile, the N-gain score for the experimental class was calculated as follows:

N-gain = (81 − 28) / (100 − 28) = 53 / 72 = 0.74

Based on these calculations, the control class obtained a moderate N-gain score, while the experimental class obtained a higher N-gain score. This finding suggests that the experimental class demonstrated greater learning improvement than the control class. Nevertheless, this result should be interpreted carefully because further statistical analysis is needed to determine whether the difference between the two classes is statistically significant.

The average normalized gain scores for the control group and the experimental group were 0.77 and 0.85, respectively. It can be concluded that the average normalized gain score for the experimental group was higher than that of the control group, as shown in Figure 5 below:

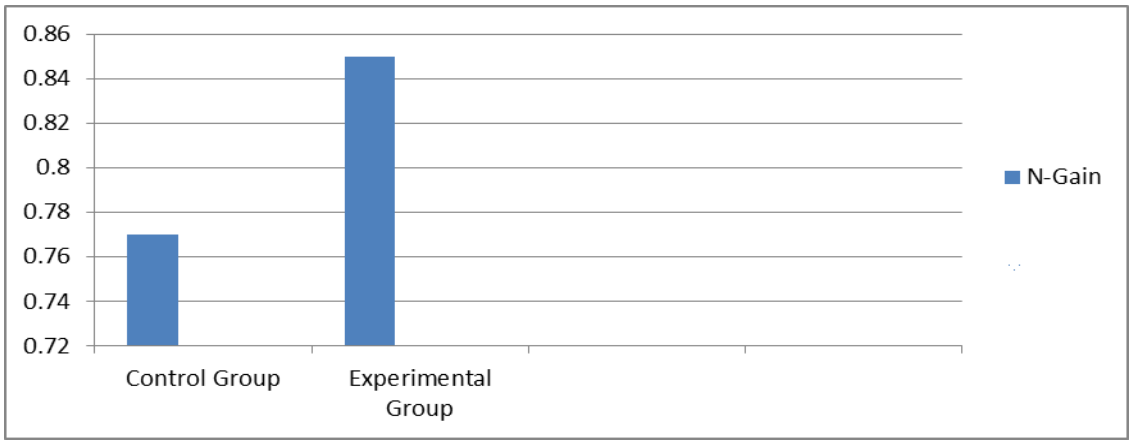

Figure 5. Average N-Gain Values for the Control Group and the Experimental Group

3.1.5 Student Motivation and Engagement during the Use of the Application

The implementation of the AI-based digital literacy application also indicated potential benefits for student motivation and engagement. During the learning process, students in the experimental class had access to interactive materials, immediate feedback, writing support, and digital literacy activities. These features may encourage students to participate more actively because they can receive direct responses from the system and revise their work based on the feedback provided.

The application also provides learning personalization through activities that allow students to practice according to their needs. Features such as writing assistance, language correction, text analysis, and interactive learning activities may help students become more engaged in the learning process. However, because this study has not presented detailed quantitative data from a motivation or engagement questionnaire, the claim that motivation and engagement increased should be understood as a preliminary observation. Future research should measure motivation and engagement using validated instruments so that the impact of the application can be reported more accurately.

3.1.6 Efficiency of the Learning Process

The use of the AI-based digital literacy application showed potential to support learning efficiency. The application provides learning materials, writing assistance, automatic feedback, and digital literacy activities in one platform. This integration may help students access learning resources more easily and complete learning activities more independently. For lecturers, the application may support the learning process by providing additional tools for practice, feedback, and student-centered learning activities.

However, the efficiency of the learning process should be interpreted as a potential benefit rather than a conclusive finding. To claim efficiency more strongly, future studies need to provide measurable indicators, such as time spent on learning tasks, completion rates, teacher workload, student response time, and comparisons between conventional and AI-supported learning activities.

3.1.7 Summary of Findings

Overall, the findings show that the study successfully produced an AI-based digital literacy application prototype for Indonesian language learning. The prototype includes learning materials, AI-assisted writing support, text analysis, language correction, digital literacy activities, and user guidance. The preliminary classroom trial showed that students in both the control and experimental classes improved their learning outcomes, with the experimental class obtaining a higher post-test score and higher N-gain score than the control class.

These findings suggest that the AI-based digital literacy application has potential as a learning medium for Indonesian language learning. Nevertheless, the results should be interpreted as preliminary because the study still requires clearer product validation data, detailed user response

analysis, statistical testing, and broader field trials. Further research is needed to confirm the effectiveness, usability, and sustainability of the application in different learning contexts.

3.2 Discussion

The findings of this study indicate that the AI-based digital literacy application prototype, Lithascyai, has the potential to support Indonesian language learning through the integration of digital learning materials, AI-assisted writing support, text analysis, language correction, and digital literacy activities. The development of this prototype responds to the growing need for learning media that are not only technology-based but also pedagogically relevant to students' language development and digital literacy competence. In contemporary education, digital literacy is no longer limited to technical ability in using devices; it also involves the capacity to evaluate information, communicate responsibly, and produce meaningful digital content (Falloon, 2020; Law et al., 2018). Therefore, the integration of Indonesian language learning and digital literacy in one application is relevant to current educational demands.

The prototype developed in this study reflects the principle that technology should function as a learning support system rather than merely as a digital substitute for printed materials. Through features such as AI writing assistance and text analysis, students are provided with opportunities to revise their work, identify language problems, and receive feedback more immediately. This is important because feedback plays a central role in language learning, particularly in writing development. AI-supported feedback may help learners recognize grammar, diction, structure, and clarity issues more efficiently. This finding is consistent with studies suggesting that AI-supported learning environments can promote more personalized and interactive learning experiences (Almatrafi et al., 2024; Ng et al., 2024).

The preliminary implementation showed that both the control and experimental classes experienced improvement from pre-test to post-test. However, the experimental class obtained a higher post-test score and higher normalized gain than the control class. This result suggests that the use of Lithascyai may have contributed positively to students' Indonesian language learning outcomes. The improvement may be associated with several factors, including access to structured digital materials, immediate feedback, interactive practice, and opportunities for independent learning. These elements are consistent with the concept of technology-enhanced learning, in which digital tools can support students' engagement, autonomy, and learning continuity beyond conventional classroom explanation (McDougall et al., 2018; Pratolo & Solikhati, 2020).

The higher learning improvement in the experimental class may also be explained by the adaptive nature of AI-based learning support. Unlike conventional materials that usually provide the same content and feedback for all learners, AI-supported applications can offer more individualized responses based on users' input. This form of personalization is important in language learning because students often have different levels of vocabulary mastery, writing ability, and understanding of text structure. Previous research has emphasized that AI in education can support adaptive learning, automated feedback, and more flexible access to learning resources (Almatrafi et al., 2024; Rajagopal & Vedamanickam, 2019). In this study, these possibilities were reflected in the application features, although further validation is still needed to examine the accuracy and pedagogical quality of the AI-generated feedback.

In terms of motivation and engagement, the application showed potential to make the learning process more interactive. Features such as writing assistance, digital literacy modules, feedback, and gamified or interactive learning activities may encourage students to participate more actively in the learning process. Interactive digital learning can increase students' involvement because it allows them to receive responses, track progress, and practice repeatedly. This supports previous findings that digital literacy-based learning can help students become more active and independent learners when the technology is designed according to learning needs (Blevins, 2018; Falloon, 2020). However, the claim that motivation and engagement increased should be interpreted carefully because the present

study has not yet reported detailed quantitative data from validated motivation or engagement instruments.

The study also has implications for the implementation of the Merdeka Curriculum. The Merdeka Curriculum emphasizes flexible learning, student-centered activities, and the development of competencies relevant to twenty-first-century education. An AI-based digital literacy application can support these principles by providing learning resources that allow students to learn independently, receive feedback, and practice language skills in a more flexible environment. In addition, the integration of digital literacy activities can help students develop critical awareness in using digital information, which is increasingly important in the era of misinformation and rapid technological change (Breakstone et al., 2018; Sari et al., 2020).

Nevertheless, several limitations should be acknowledged. First, the findings are preliminary and should not be interpreted as conclusive evidence of effectiveness. Although the experimental class showed higher improvement, further statistical analysis is needed to determine whether the difference between the control and experimental classes is significant. Second, the study needs to provide clearer validation results from material experts, media experts, and users to support claims about product feasibility. Third, the technical dimension of the AI system requires more detailed explanation, including how the feedback is generated, how accuracy is checked, and how user data are protected. These issues are important because AI use in education involves not only instructional effectiveness but also ethical concerns related to transparency, privacy, and reliability.

Overall, this study suggests that Lithascyai has potential as an AI-based digital literacy application for Indonesian language learning. The prototype offers a promising direction for integrating language learning, digital literacy, and AI-supported feedback. However, broader trials, stronger validation procedures, more rigorous statistical analysis, and clearer ethical safeguards are needed before the application can be recommended for wider implementation. Future research should involve larger samples, diverse educational contexts, validated motivation and usability instruments, and systematic evaluation of AI feedback quality.

4. CONCLUSION

This study developed and preliminarily evaluated Lithascyai, an AI-based digital literacy application prototype designed to support Indonesian language learning through learning materials, AI-assisted writing support, text analysis, language correction, adaptive feedback, and digital literacy activities. The main finding indicates that the prototype has potential as a learning medium, as students in the experimental class who used the application showed higher post-test scores and higher learning improvement than those in the control class using conventional learning materials. The application also appeared to support more interactive and independent learning by providing students with access to digital materials and immediate feedback during the learning process. However, this study has several limitations, including the limited scope of the trial, the absence of broader implementation across different educational contexts, limited statistical evidence of effectiveness, and the need for more detailed validation of the AI-generated feedback, usability, motivation, engagement, and data privacy aspects. Therefore, future research should involve larger and more diverse samples, conduct rigorous statistical testing, include expert and user validation, use validated instruments to measure motivation and engagement, and examine the accuracy, ethical use, and long-term effectiveness of AI-based digital literacy applications in Indonesian language learning.

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