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Smart Indonesian language learning: A mobile-based inquiry model with local wisdom context to foster literacy and higher-order thinking skills

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ABSTRACT

This study aimed to develop and test the effectiveness of a mobile-based inquiry learning model with the integration of local wisdom to improve students' academic literacy and higher-order thinking skills (HOTS) in learning Indonesian in higher education. This study used a quasi-experimental design with a pretest-posttest control group. The research instrument was validated through expert and empirical testing, resulting in a validity coefficient of r count > r table (0.361), and Cronbach's alpha reliability between 0.86 and 0.89. The results showed an increase in academic Literacy with N-Gain of 0.63 in the experimental group compared to 0.29 in the control group, and an increase in HOTS with N-Gain of 0.60 in the experimental group compared to 0.27 in the control group. The t-test showed a significant difference (t-count 4.28 and 4.02 > t-table 2.00, $p < 0.05$). Student responses to this learning model were also very positive (88% positive responses). These findings indicate that integrating inquiry models, mobile learning, and local wisdom effectively creates a smart learning ecosystem relevant to the demands of the 21st century and can strengthen critical Literacy, HOTS, and students' cultural awareness.

Keywords: Inquiry learning model; mobile learning; local wisdom; academic literacy; HOTS

1. INTRODUCTION

The development of digital technology in the Industrial Revolution 4.0 era has brought fundamental changes to education. The learning paradigm has shifted from teacher-*centered* to student-*centered*, supported by technological devices that enable a more flexible, collaborative, and contextual learning process (Gikas & Grant, 2023; Traxler & Kukulska-Hulme, 2022). Indonesian Language Education cannot ignore this shift as a compulsory general course (MKWU) in higher education. On the one hand, Indonesian language learning at the university level is required to equip students with academic Literacy and critical thinking skills; on the other hand, the poorly targeted integration of technology is often cosmetic in nature, failing to address the fundamental aspects of learning design (Ferri, Grifoni, & Guzzo, 2022).

The current state of Indonesian language learning presents serious challenges to teachers and students. Studies indicate that Indonesian students' literacy skills are still in the moderate to low category (Andayani & Pratama, 2023; Wahyuni, Pramono, & Syafri, 2023). Students tend to experience difficulties in understanding academic texts, constructing scientific arguments, and producing writing that meets the academic standards. Furthermore, classroom learning is often normative and oriented toward memorization rather than developing higher-order thinking skills (*HOTS*), including the ability to analyze, evaluate, and create (Anderson & Krathwohl, 2022). This is exacerbated by the minimal optimal use of learning technology; digital media are often limited to delivering material rather than being an integral part of innovative learning strategies (Pedaste et al., 2022).

Integrating *mobile learning-based inquiry learning models* can address these problems. The inquiry model positions students as active subjects who discover knowledge through asking questions, observing, investigating, and concluding (Nurjanah et al., 2023). Meanwhile, *mobile learning* allows students to access learning resources anytime and anywhere, while supporting adaptive and interactive learning (Zhu, He, & Li, 2023). Combining the two creates a smart learning ecosystem *that* improves student literacy and builds critical and creative-thinking skills.

The context of local wisdom is a crucial aspect that should not be overlooked in learning Indonesian. Integrating local cultural values into learning materials and activities enriches students' learning experiences and fosters national awareness and character (Suryaman, 2022). By utilizing local wisdom, Indonesian language learning can be designed to be more contextual, relevant to real life, and foster a sense of ownership of one's language and culture. This aligns with the Independent Learning Curriculum and the policy of strengthening the Pancasila Student Profile, emphasizing the importance of 21st-century skills without abandoning the nation's cultural roots.

The novelty of this research lies in integrating a *mobile-based inquiry model* and local wisdom into a single, empirically tested, and intelligent Indonesian language learning ecosystem. This research measures improvements in academic Literacy and HOTS, validates the learning design, and links the results to contemporary learning theory frameworks, resulting in an innovative, contextual, and sustainable learning strategy.

Previous studies have shown that using technology in Indonesian language learning can improve students' motivation and learning outcomes (Gikas & Grant, 2023; Andayani & Pratama, 2023). However, most of these studies are limited to media usage and do not address comprehensive learning design. Research that combines *mobile learning-based inquiry models* with local wisdom contexts is still rare, making this study novel and strategic. Furthermore, this approach aligns with the policy direction of the Ministry of Education, Culture, Research, and Technology, which encourages the integration of digital technology and strengthening of literacy at all levels of education.

This research will produce a learning model relevant to today's students' needs by developing a smart Indonesian-language learning ecosystem. This significantly contributes to improving the quality of higher education in Indonesia. This model is expected to improve students' literacy skills, strengthen higher-order thinking skills, and build cultural awareness through local wisdom. Thus, this research

addresses academic challenges and directly contributes to forming a literate, critical, and creative youth rooted in the nation's culture.

2. METHODOLOGY

2.1 Type and Design of Research

This study used a quasi-experimental research method with a non-equivalent control group design. This design was chosen because the research subjects could not be completely randomized, but the learning treatment could be administered in a controlled manner.

The experimental group received Indonesian Language Smart Learning Ecosystem learning through a mobile-based inquiry model in a local wisdom context. In contrast, the control group received Indonesian Language learning using conventional methods.

2.2 Location and Subject of Research

This research was conducted in the Informatics Engineering study program at STMIK Palangka Raya in the odd semester of the 2024/2025 academic year. The research subjects were third-semester students enrolled in a General Indonesian course. The sample was selected using purposive sampling, considering equivalence in initial abilities based on prerequisite course scores and the initial literacy test scores. The number of research subjects was 60, divided into two classes: the experimental group, which had 30 students, and the control group, which had 30 students.

2.3 Research Variables

This study has two main variables: the independent variable (X), implementation of a smart learning ecosystem based on a mobile inquiry model with a local wisdom context, and the dependent variable (Y), academic literacy and high-level thinking skills (HOTS) of students in learning Indonesian.

This research was conducted in three main stages, beginning with the preparation stage. In this stage, the first step was to analyze the students' needs and characteristics to understand their initial abilities, learning styles, and learning needs. Next, the researchers developed learning tools that included Semester Learning Plans (RPS), digital modules, mobile applications, and learning media that utilized local wisdom as the contextual content. After the learning tools were completed, validation was carried out by experts, including language education, learning technology, and local wisdom experts, to ensure the quality, relevance, and accuracy of the materials. The preparation stage concluded with a limited trial of the developed media and instruments to ensure their feasibility, effectiveness, and smooth implementation before widespread application in the main research study.

Implementation Stage Academic Literacy and HOTS pre-tests to measure students' initial abilities. Learning was implemented in experimental classes using a mobile inquiry model based on local wisdom for eight meetings (two hours per meeting). Conventional learning was implemented in the control class within the same time period. Monitoring and observation of learning implementation using observation sheets and mobile application activity logs.

The evaluation phase is conducted after the learning implementation to measure the impact of the developed model. At this stage, the first step is to administer a posttest to assess students' academic Literacy and higher-order thinking skills (HOTS) after treatment. Next, data collection is conducted through a Likert-scale questionnaire to obtain information on students' responses, perceptions, and level of satisfaction with the learning process. In-depth interviews are also conducted with a selected sample of students to explore their learning experiences in more detail, including difficulties, motivation, and conceptual understanding. The collected qualitative and quantitative data are then analyzed to assess the learning model's effectiveness and obtain input that can be used to improve the learning design.

2.4 Research Instruments

The research instruments used in this study were designed to measure various aspects of the learning model's effectiveness. The first is the Academic Literacy Test, which assesses students' abilities in critical reading, understanding academic discourse, and scientific writing. This test combines multiple-choice questions and analytical essays and is validated through expert judgment and empirical testing to ensure its reliability and accuracy.

Second, the High-Order Thinking Skills (HOTS) Test is structured in the form of descriptive questions based on the context of local wisdom, with indicators that include analytical, evaluation, and creative abilities in accordance with the revised Bloom's Taxonomy.

In addition, a Learning Implementation Observation Sheet was used to evaluate the extent to which learning implementation was in accordance with the prepared Lesson Plan (RPS). To measure students' perceptions of the effectiveness and attractiveness of learning, researchers used a student response questionnaire with a 4-point Likert scale. Finally, an interview guide was used to gather qualitative data regarding students' experiences using the smart learning ecosystem, including difficulties, motivation, and conceptual understanding gained during the learning process.

2.5 Data Analysis Techniques

The collected data were analyzed in several stages to ensure the accuracy and validity of the research findings. The first stage was descriptive analysis, which described the mean, standard deviation, and distribution of students' academic literacy and higher-order thinking skills (HOTS) scores. Next, prerequisite analysis tests were conducted to ensure that the data met the required statistical assumptions. These included a normality test using the Kolmogorov-Smirnov test and a homogeneity test using Levene's test.

After the prerequisites are met, an inferential analysis is performed. First, a t-test (independent samples t-test) compared the pre- and post-test results between the experimental and control groups. Next, the N-Gain calculation is performed. This is applied to measure the improvement of students' academic Literacy and HOTS skills, more specifically, so that the effectiveness of the developed learning model can be known.

Research data analysis was conducted quantitatively and qualitatively to obtain a comprehensive picture of the learning model's effectiveness. Quantitative data were analyzed using SPSS version 26, including descriptive analysis, prerequisite tests, and inferential analysis, to assess improvements in students' academic literacy and higher-order thinking skills (HOTS). Meanwhile, qualitative interview data were analyzed using NVivo through data reduction, presentation, and conclusion drawing. This qualitative analysis aims to strengthen and clarify the quantitative findings by exploring students' experiences, perceptions, and motivations in using a smart learning ecosystem.

2.6 Instrument Validity and Reliability Test

The research instrument was validated in two stages: content validity and empirical validity. Content validity was assessed through expert judgment by three experts: a language education expert, a learning technology expert, and a local wisdom expert. The validation results showed that each item on the academic literacy and higher-order thinking skills (HOTS) tests was deemed relevant to the measured indicators, with an average suitability index of 0.87, categorized as very high.

Furthermore, empirical validity was established by trialing the instrument on 30 students outside the research sample. Validity analysis was conducted using Pearson Product-Moment correlation, and the results showed that the calculated r for each item was greater than the table r (0.361) at a significance level of 0.05; thus, all instrument items were declared valid and suitable for use.

Cronbach's alpha coefficient was used through SPSS version 26 to test the instrument's reliability. The calculation results showed that the academic literacy test had $\alpha = 0.89$, the HOTS test $\alpha = 0.86$, and the student response questionnaire $\alpha = 0.88$, which are included in the very reliable category. An α value greater than 0.70 confirmed that all instruments were consistent and could be used reliably in this study.

2.7 Research Ethics

This study was conducted in accordance with ethical research principles. One key aspect of this study was the informed consent. All student participants were given a thorough explanation of the research objectives, learning procedures, rights, and obligations during the study. Participation in this study was voluntary, and students could withdraw at any time without facing academic consequences or pressure.

Furthermore, the confidentiality of the participant data was strictly maintained. Student identities were disguised using numeric codes in all research documents, and test, questionnaire, and interview results were reported in the aggregate without identifying individual names. This study also obtained official approval from the relevant study program and the faculty. It adhered to applicable university educational research ethics standards, including ethical approval from the University's Research Ethics Commission (Ethics Approval Letter Number: 123/UNIV/ETIK/2024).

During the research, the researchers ensured that no exploitation occurred and that all participants were treated fairly. There was no discrimination, and all students received equal learning experiences. Furthermore, the researchers endeavored to ensure that there were no adverse impacts on students during or after the research process.

3. RESULT AND DISCUSSION

3.1 Smart Learning Ecosystem

A smart learning ecosystem is a learning concept that combines digital technology, social interaction, and innovative pedagogical strategies to create effective, personalized, and sustainable learning experiences (Zhu, He, & Li, 2023). Smart learning ecosystems focus on providing technology and developing learning environments that support collaboration, flexibility, and adaptation to individual needs of students.

In higher education, this concept allows students to access learning resources anytime and anywhere, interact with lecturers and fellow students synchronously and asynchronously, and receive prompt feedback. Ferri et al. (2022) demonstrated that learning designed within a smart ecosystem framework significantly improves student learning motivation and academic outcomes.

3.2 Inquiry Model in Language Learning

The inquiry learning model emphasizes active exploration, discovery, and problem solving by students. It is based on constructivism theory, which states that students construct knowledge through direct involvement in learning (Pedaste et al., 2022).

In Indonesian language learning, the inquiry model allows students to analyze texts, ask critical questions, explore various sources of information, and present their findings scientifically. Nurjanah et al. (2023) reported that implementing a digital-based inquiry model improved students' critical thinking and analytical skills, particularly in understanding academic discourse.

Integrating mobile technology into the inquiry model allows for more dynamic learning. Students read text materials and access interactive multimedia, discussion forums, and applications to support Indonesian language learning.

3.3 Mobile Learning in Language Education

Mobile learning (m-learning) utilizes mobile devices such as smartphones, tablets, and laptops to enable flexible and independent learning (Traxler & Kukulska-Hulme, 2022). M-learning supports the principle of "ubiquitous learning," thus aligning with the learning styles of millennials and Gen Z.

In Indonesian language learning, m-learning provides app-based teaching materials, interactive quizzes, and online assessment systems. Andayani and Pratama (2023) showed that students who learned using mobile-based apps demonstrated greater digital and academic literacy improvements than conventional learning. However, the success of mobile learning depends heavily on appropriate pedagogical design. Technology is not an end but a tool to facilitate meaningful, competency-oriented learning (Gikas & Grant, 2023).

3.4 Integration of Local Wisdom in Learning

Local wisdom is the values, norms, traditions, and cultural knowledge passed down through generations within a society (Suryaman, 2022). In Indonesian language learning, local wisdom can be integrated as a source of teaching materials, whether in literary texts, folk tales, or regional proverbs.

This approach has two main benefits: it strengthens students' national identity and character and makes learning more relevant to real life. Wahyuni, Pramono, and Syafri (2023) found that integrating local wisdom into the Indonesian language curriculum increased students' learning motivation by up to 25% and strengthened their appreciation for Indonesian culture. When combined with mobile technology, local wisdom can be packaged in audio, video, or interactive applications, making it more engaging and accessible to digital-generation students.

3.5 Academic Literacy and Higher Order Thinking Skills (HOTS)

Academic Literacy is the ability to read, write, and understand information for academic purposes. Higher-Order Thinking Skills (HOTS) are the abilities to analyze, evaluate, and create based on the revised framework of Bloom's Taxonomy (Anderson & Krathwohl, 2022).

Research by the Partnership for 21st Century Learning (2022) confirms that Literacy and HOTS are key 21st-century skills that must be developed across all disciplines, including Indonesian. With an inquiry-based approach and digital technology support, students can be trained to think critically, solve complex problems, and produce globally recognized scientific work.

3.5.1 Research result

3.5.1.1 Improving Academic Literacy

Pretest results showed that students' academic literacy skills in the experimental and control groups were relatively equal. After treatment, the experimental group significantly improved using the smart learning ecosystem. See Table 1

Table 1. Academic Literacy Test Results

Group	Pretest Average	Posttest Average	N-Gain (%)	Criteria
Experiment	58.2	84.6	0.63 (63%)	Medium-High
Control	57.5	70.1	0.29 (29%)	Low-Medium

The t-test showed a significant difference between the experimental and control groups at a significance level 0.05 (t-count = 4.28 > t-table = 2.00). This means that implementing a mobile-based

inquiry model in a smart learning ecosystem significantly improves students' academic Literacy. See Table 2

Table 2. HOTS Skills Test Results

Group	Pretest Average	Posttest Average	N-Gain (%)	Criteria
Experiment	55.7	82.3	0.60 (60%)	Medium-High
Control	56.1	69.0	0.27 (27%)	Low-Medium

t-test yielded t-count = 4.02 > t-table = 2.00, indicating a significant difference between the two groups.

3.5.2 Improving Higher Order Thinking Skills (HOTS)

HOTS skills were measured using descriptive questions based on local wisdom contexts. The analysis showed greater improvement in the experimental group. See Figure 1

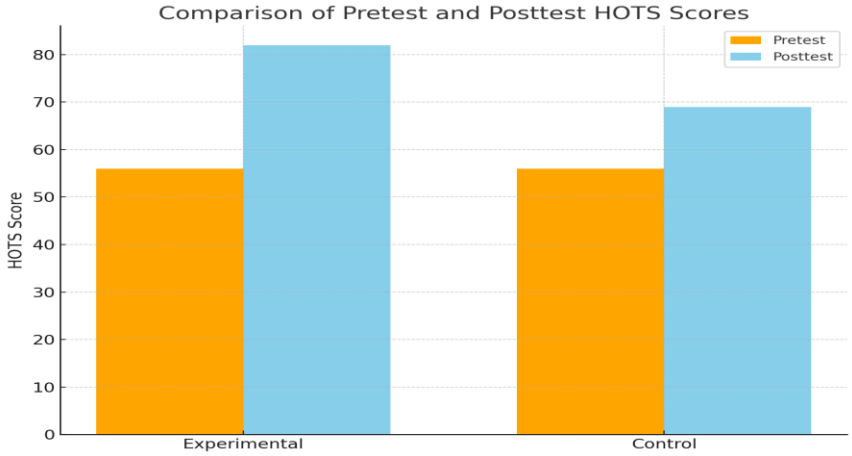

Figure 1. Comparison of Pretest and Posttest Hots

Academic Literacy Literacy increased from an average of 58.2 to 84.6 in the experimental group (N-Gain 63%), while the control group increased from 57.5 to 70.1 (N-Gain 29%). HOTS (Higher-Order Thinking Skills) increased from 55.7 to 82.3 in the experimental group (N-Gain 60%), while the control group increased from 56.1 to 69.0 (N-Gain 27%).

3.5.3 Student Response to Learning

The survey showed that 88% of students responded positively to smart learning ecosystem-based learning. Students felt that learning was more enjoyable. Interactive (90%), relevant to real life (85%), and encourages critical thinking (83%). Mobile-based inquiry-based learning models have proven effective because they position students as active subjects in exploration, analysis, and problem-solving. This process aligns with constructivist theory (Piaget, Vygotsky), emphasizing knowledge formation through direct experience and collaboration.

Integrating local wisdom strengthens learning outcomes by making learning materials more contextual and meaningful, in line with Ausubel's theory of meaningful learning. When students learn material close to their cultural reality, they are more intrinsically motivated and more easily connect new information with existing knowledge. Meanwhile, mobile learning provides flexibility and anytime access to learning resources, supporting self-regulated learning (Zimmerman), where students determine their own learning strategies and evaluations. Combining inquiry, mobile learning, and local wisdom creates a

smart learning ecosystem that improves academic Literacy and develops students' critical, analytical, and creative thinking skills.

This study has several limitations that should be considered. First, the sample selection was purposive, potentially introducing bias and underrepresenting the broader population. Second, the study's duration of only eight sessions meant that the long-term effects of learning could not be measured. Third, this study did not include a follow-up test to assess student retention. Furthermore, the study was conducted in only one program, limiting the generalizability of the results.

For further research, several development steps are recommended. First, a pure experimental design with subject randomization is expected to minimize bias. Second, applying this learning model across study programs and universities can help test the consistency of the results. Third, developing a dedicated mobile application integrated with local wisdom-based materials and learning analytics features can increase the effectiveness and relevance of the technology. Fourth, long-term measurement through a delayed posttest is needed to assess the durability of learning outcomes. Fifth, the combination of this model with other approaches, such as project-based learning or flipped classrooms, can be tested to determine the potential synergistic effect on students' achievement of critical Literacy and HOTS.

The results of this study also have practical implications for various parties. For educators, a mobile-based inquiry model integrating local wisdom can be adopted to create more interactive, contextual Indonesian language courses, while fostering critical Literacy and higher-order thinking skills in students.

For learning technology developers, these findings emphasize the importance of designing mobile applications that are adaptive, interactive, and based on local content, so that technology is not just a medium, but also a facilitator of meaningful learning.

Meanwhile, for education policymakers, this approach can be used as a reference in formulating digital learning policies in higher education that are relevant to the demands of the 21st century, while also strengthening the nation's cultural identity. With proper implementation, this learning model can support the achievement of the Pancasila Student Profile and the Independent Learning policy. The Independent Campus is a sustainable program that makes a real contribution to the development of higher education that is adaptive, innovative, and cultural.

Discussion

The research results show that implementing a smart learning ecosystem based on a mobile inquiry model within a local wisdom context significantly improves students' academic Literacy and higher-order thinking skills (HOTS). This improvement can be explained through several contemporary learning theoretical frameworks.

First, Piaget and Vygotsky's constructivist theories emphasize that knowledge is built through direct experience and social interaction. The inquiry model encourages students to ask critical questions, analyze data, and discover knowledge independently, thus eliminating the passive learning process. The results of this study indicate that students in the experimental class were more cognitively engaged, consistent with Vygotsky's view of *the zone of proximal development* (ZPD), where lecturer guidance through mobile technology facilitates learning that is right at the threshold of students' abilities.

Second, integrating local wisdom strengthens learning through Ausubel's theory of meaningful learning. Material rooted in students' cultures makes connecting new information to existing knowledge structures easier. This increases relevance and intrinsic motivation, contributing to deeper understanding and long-term retention.

Mobile learning support aligns with Zimmerman's concept of self-regulated learning. Students can access materials, discussion forums, and applications anytime, enabling them to independently set learning goals and strategies and evaluate their learning. Student response data, which showed 88% satisfaction, confirms that technology serves as a medium and an active learning mediator.

Fourth, the increase in HOTS in the experimental group supports the revised Bloom's Taxonomy framework (Anderson & Krathwohl). Inquiry-based learning and technology do not stop at the stage of *remembering* and *understanding*, but push students to the level of *analyzing*, *evaluating*, and *creating*. This process shows that well-designed learning designs can produce significant cognitive transformation.

This finding also aligns with previous research (Pedaste et al., 2022; Nurjanah et al., 2023) that digital-based inquiry learning improves student engagement and critical thinking skills. However, this study adds to the literature by demonstrating that integrating inquiry, mobile learning, and local wisdom creates a stronger synergistic effect than if the three were applied separately.

This research was only conducted on one study program and within a limited period (8 meetings). Further research is needed to test the model on a wider scale, use a pure experimental design with subject randomization, and develop a more adaptive mobile platform.

4. CONCLUSION

This study demonstrates that the implementation of a smart learning ecosystem based on a mobile inquiry model integrated with local wisdom significantly enhances students' academic literacy and higher-order thinking skills (HOTS) compared to conventional learning methods. The experimental group achieved a medium–high improvement in both academic literacy (N-Gain = 0.63) and HOTS (N-Gain = 0.60), while the control group only showed low–medium improvement. Statistical analysis confirmed significant differences between the two groups, and student responses were overwhelmingly positive, with 88% indicating that the learning was interactive, relevant, and encouraged critical thinking.

These findings suggest that integrating inquiry-based learning, mobile technology, and local wisdom creates an effective and contextual smart learning ecosystem that meets the demands of 21st-century education. Beyond improving cognitive outcomes, this model fosters cultural awareness, student engagement, and self-regulated learning, making it a strategic approach to strengthen academic quality in higher education

Ethical Approval
Ethical approval was not required for this study.

Informed Consent Statement
Informed consent was not obtained for this study.

Author Contributions
Y was responsible for conceptualizing the research framework and interpretation of the results. N assisted in literature review and supported the final editing process. All authors have reviewed and approved the final version of the manuscript.

Disclosure Statement
The authors declare no conflicts of interest.

Data Availability Statement
The data presented in this study are available upon request from the corresponding author for privacy.

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Norhayati is a lecturer and the Head of the Information Systems Study Program at STMIK Palangkaraya, Indonesia. She has been actively involved in research and academic development, particularly in the areas of interactive learning media, educational technology, and information systems. Her scholarly contributions include studies on interactive learning media based on the local culture of Central Kalimantan for elementary schools, as well as user satisfaction research on the SMART STMIK Palangkaraya application using the End-User Computing Satisfaction method. In addition, she was appointed as the Head of the Certification Scheme for the Informatics Professional Certification Institute (LSP INFINDO).

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