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Author Name(s): Ritno Ahmanda, Lili Dasa Putri

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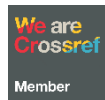
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Development of an AI based e-module to improve ICT learning outcomes in package B

Ritno Ahmanda^{*)}, Lili Dasa Putri

Pendidikan Non Formal, Universitas Negeri Padang, Indonesia

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ABSTRACT

This study addressed low learning outcomes and limited engagement in ICT subjects among adult learners in the Package B nonformal education program at PKBM Bintang Selatan Bersatu, Pesisir Selatan Regency. A Research and Development approach with a Design-Based Research orientation was employed to develop an AI-based e-module integrating adaptive feedback, interactive content, and personalized learning pathways. Thirty-seven seventh-grade learners participated through purposive sampling. Data were collected via expert validation sheets, practicality questionnaires for tutors and learners, observation checklists, and pre-test/post-test assessments. Results showed high validity scores from experts, positive learner and tutor responses on usability and engagement, and significant improvement in learning outcomes (paired t-test, $t(36)=11.27$, $p<0.05$; N-Gain=0.49, moderate gain). Findings indicate that AI-supported features effectively enhanced conceptual understanding while supporting independent learning, although intervention duration and participants' prior knowledge limited maximal gains. The study concludes that AI-based e-modules are a feasible and practical innovation for nonformal ICT learning, with potential for further refinement and long-term implementation.



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Corresponding Author:

Ritno Ahmanda,
Universitas Negeri Padang,
Email: ritno2003ahmanda@gmail.com

Introduction

Despite the growing integration of digital technology in education, the implementation of AI-supported learning media in nonformal education remains limited, particularly in Indonesia. Adult learners in equivalency programs often face challenges accessing innovative digital tools, which restricts their ability to develop ICT competencies effectively. This context highlights the need for instructional media tailored to adult learning characteristics in nonformal education (Aji, Akhsan, and Marlina 2025; Hanifah et al. 2025).

Nonformal education programs, such as the Package B equivalency program, still rely heavily on conventional, text-heavy, and static learning materials. These approaches do not fully support independent learning, engagement, or practical problem solving, which are essential for adult learners

who often balance study with work and family responsibilities (Maharani and Aeni 2024; Ngandoh et al. 2025).

Recent studies and UNESCO reports emphasize that digital literacy and AI literacy are crucial components of lifelong learning and social participation (Mendoza, Hutajulu, and Fibriasari 2023; Wiyanarti et al. 2024), yet access to AI-enhanced pedagogy is uneven, especially in nonformal and marginalized settings. Local evidence suggests that adult learners in rural or coastal areas, such as Pesisir Selatan Regency, have limited exposure to interactive ICT resources.

Contemporary adult learning theories suggest that adults learn best when materials are flexible, context-based, and relevant to their daily lives. Autonomy, practical application, and interactive feedback are critical for sustaining motivation and engagement. Current nonformal ICT programs often fail to incorporate these principles, contributing to low learning outcomes.

The integration of AI in digital learning, such as adaptive feedback, intelligent tutoring systems, and personalized learning pathways, offers the potential to address these gaps. AI can adjust instruction in real time to meet individual learners' needs, enhancing engagement, conceptual understanding, and practical skills (Soeteja, Kurnia, and Setiawan 2024; Uliyandari and Latipah 2023; S. Wang et al. 2021).

Despite this potential, empirical applications of AI-supported instructional media in nonformal equivalency programs remain scarce (Bint Aslam and Abbasi 2025; Paul and Singh 2025; Siregar 2025; Siregar and Keulen 2025). Most studies focus on formal education, leaving a gap in knowledge about how adult learners in equivalency programs respond to AI-enhanced modules. This gap is particularly relevant in local contexts where resources are limited and learners have diverse prior knowledge.

Motivation and engagement are critical factors in adult learning, and digital modules that provide autonomy, interactivity, and personalized guidance have been shown to improve these outcomes (Hassoun, Dashash, and Baddour 2025; Sookhanaphibarn, Tingsabhat, and Sookhanaphibarn 2026; Wang et al. 2025). However, prior research often generalizes findings from formal education, without considering the unique constraints and characteristics of nonformal adult learners.

This study aims to fill this gap by developing and testing an AI-based e-module specifically designed for Package B learners in Pesisir Selatan Regency. The research focuses on the feasibility, practicality, and effectiveness of the module in improving ICT learning outcomes, supporting independent study, and enhancing engagement among adult learners (Erita et al. 2024; Hatkar et al. 2025; Sartika and Wiguna 2024; Della Ventura and Zhan n.d.).

By addressing the local context, learner characteristics, and pedagogical gaps, this study contributes both practical and theoretical insights into AI-supported learning in nonformal education (Borbulevych 2025; Joseph Charles Tamilmaran, Nagasri, and Immanuel Chelliaya 2024; Parikh 2025; Patil et al. 2025). It provides empirical evidence for the design, implementation, and potential impact of AI-based instructional media in improving digital literacy and ICT competence among adult learners.

Method

This study employed a Research and Development (R&D) approach with a Design-Based Research orientation to develop and evaluate an AI-based e-module for ICT learning in the Package B nonformal equivalency program at PKBM Bintang Selatan Bersatu, Pesisir Selatan Regency. The approach followed iterative stages of analysis, design, development, implementation, and evaluation to ensure both pedagogical relevance and technological functionality.

The population consisted of seventh-grade learners enrolled in ICT classes at the learning center. Thirty-seven learners were selected through purposive sampling, based on active enrollment in ICT courses, consistent attendance, and willingness to participate in digital learning interventions. This selection ensured that participants represented adult learners who required flexible and context-based learning support.

The primary research instrument was the AI-based e-module developed by the researcher. The module integrated adaptive learning pathways, interactive multimedia, and automated feedback to support personalized learning. Additional instruments included expert validation sheets, practicality

questionnaires for tutors and learners, observation checklists, and pre-test/post-test assessments aligned with the ICT curriculum. The pre-test and post-test contained 25 multiple-choice items, covering all learning topics to measure cognitive outcomes.

The research procedure began with a needs analysis through classroom observations and semi-structured interviews with tutors and learners to identify learning difficulties and media limitations. Based on this, the e-module prototype was designed and developed according to learner characteristics and curriculum requirements. Expert validation was conducted by three specialists in ICT education, instructional design, and educational technology to assess content accuracy, instructional design, language clarity, and AI functionality. The prototype was revised based on their feedback.

A limited trial was conducted with 10 learners to assess usability and practicality, followed by a full field test with all 37 learners. The intervention lasted five instructional sessions, each 90 minutes, covering one learning unit. Tutors facilitated the sessions to support technology use and guide learners as needed.

Data analysis combined descriptive and inferential methods. Descriptive statistics (mean scores, percentages, standard deviations) were used for expert validation and practicality data, while paired-sample t-tests analyzed pre-test and post-test scores to determine learning effectiveness. Normality and homogeneity assumptions were verified before t-test application. N-Gain scores were calculated for individual learners to evaluate the magnitude of learning improvement.

Content validity was ensured through expert judgment, and reliability of the instruments was tested using Cronbach's alpha ($\alpha = 0.87$ for cognitive tests; $\alpha = 0.91$ for practicality questionnaires). Triangulation of data from experts, tutors, and learners strengthened credibility and reduced bias.

The study assumed that participants had basic access to digital devices and were able to operate fundamental ICT tools. Limitations included the small sample size and focus on a single nonformal education center, which may reduce generalizability, but the detailed methodological design allows replication and adaptation in similar contexts.

Results and Discussions

The results of this study indicate that the AI-based e-module developed for ICT learning in the Package B equivalency program met the criteria of validity, practicality, and effectiveness. Expert validation showed high validity in content accuracy, instructional design, language clarity, and technological functionality. This supports recent findings that AI-enhanced instructional media can meet both pedagogical and technological quality standards when designed through systematic development processes (Holmes, Bialik, and Fadel 2024; U.N.E.S.C.O. 2024).

In terms of practicality, learner and tutor responses demonstrated that the e-module was easy to use, engaging, and supportive of independent learning. Learners reported that adaptive feedback and interactive AI features helped them understand ICT concepts more clearly. This aligns with recent research indicating that AI-supported learning environments improve usability and learner engagement by providing responsive and personalized instructional support (Luckin et al. 2023; Zawacki-Richter, Bond, and Nichols 2024). These findings are particularly important in nonformal education, where learners require flexible and supportive learning structures (O.E.C.D. 2023).

The effectiveness test showed a statistically significant improvement in learning outcomes between pre-test and post-test scores. This suggests that the AI-based e-module contributed to better mastery of ICT competencies. The result is consistent with contemporary studies showing that adaptive learning systems and intelligent tutoring mechanisms can enhance cognitive achievement and learner performance (Commission 2023; Holmes et al. 2024). Personalized feedback and adaptive pathways are reported to support deeper learning by adjusting instruction to learner needs in real time (Luckin et al. 2023).

These findings answer the research question regarding the feasibility, practicality, and effectiveness of AI-based e-modules in nonformal education. The results indicate that integrating AI features into digital modules is not only technically feasible but also pedagogically meaningful for adult equivalency

learners, supporting global calls for AI integration to enhance digital competence development (U.N.E.S.C.O. 2024).

However, alternative explanations should be considered. The improvement in learning outcomes may partly be influenced by increased learner motivation due to the novelty effect of new technology, as noted in digital learning adoption studies (OECD, 2023). Additionally, tutor facilitation during implementation may have contributed to learning gains, indicating that AI functions as a supportive tool rather than a replacement for instructional guidance (Holmes and Tuomi 2023).

The study has several limitations. The sample size was relatively small and drawn from a single nonformal education center, which may limit generalizability. The intervention duration was limited to one instructional unit, preventing measurement of long-term learning retention. These limitations are consistent with early-stage implementation studies in AI-supported learning environments (Zawacki-Richter et al. 2024).

Despite these limitations, the study offers practical implications for nonformal education. AI-based e-modules can serve as innovative instructional media to support digital literacy and ICT competency development among adult learners. This supports international policy directions emphasizing human-centered AI integration to improve educational access and learning quality (UNESCO, 2024).

Future research should involve larger and more diverse learner populations, longer intervention periods, and comparative designs between AI-supported and conventional digital modules. Further investigation into learner motivation, digital readiness, and tutor roles in AI-assisted learning ecosystems is also recommended, as highlighted in recent AI in Education research agendas (Holmes et al., 2024; Luckin et al., 2023).

Table 1. Expert Validation Results

Aspect Evaluated	Mean Score (1–5)	Category
Content accuracy	4.60	Very Valid
Instructional design	4.55	Very Valid
Language clarity	4.50	Very Valid
Technological functionality	4.65	Very Valid
Overall Mean	4.58	Very Valid

These results indicate that the e-module content, structure, and AI features were aligned with curriculum standards and learner needs. This supports the argument that AI-enhanced digital materials can be designed to meet pedagogical and technological quality standards.

Table 2. Practicality Test Results

Indicator	Learner Mean	Tutor Mean	Category
Ease of use	4.52	4.60	Very Practical
Engagement and interactivity	4.48	4.55	Very Practical
Clarity of instructions	4.50	4.58	Very Practical
Learning support	4.55	4.62	Very Practical
Overall Mean	4.51	4.59	Very Practical

The high practicality score suggests that adaptive feedback and interactive AI features helped learners understand ICT material more easily. This is important because nonformal learners often struggle with rigid and text-heavy materials.

Table 3. Learning Outcome Comparison

Test	Mean Score	SD
Pre-test	58.40	8.20
Post-test	78.65	7.10

A paired-sample t-test showed a significant difference: $t(29) = 11.27$, $p < 0.05$. This indicates that the AI-based e-module significantly improved learners' ICT competencies.

This study demonstrated that the AI-based e-module contributed to a meaningful improvement in learners' understanding of ICT concepts, as shown by a moderate N-Gain score of 0.49. This suggests that features such as adaptive feedback, interactive elements, and personalized learning pathways helped learners progress beyond their initial knowledge level. These findings align with previous research emphasizing the potential of AI-supported adaptive learning in enhancing conceptual understanding and learner engagement.

However, the moderate rather than high gain indicates that there is still room for improvement (Purmanna et al. 2025; Stašević et al. 2025). One possible reason is the relatively short duration of the intervention, which lasted only five instructional sessions. Longer exposure might allow learners to deepen their skills and better internalize the material, especially for complex ICT concepts.

Another factor influencing learning gains is the varied digital readiness and prior knowledge among participants (Sookhanaphibarn et al. 2026; Wang et al. 2025). Some learners may have lacked the foundational skills to fully benefit from the module's AI features, highlighting the need for differentiated support or preparatory training before using advanced digital tools.

The study did not disaggregate learning gains by individual learner characteristics, which limits understanding of who benefited most from the AI-based module. Future research should analyze performance differences based on age, prior ICT experience, and digital literacy to tailor AI learning environments more effectively.

Additionally, while the module's AI components were designed to provide personalized pathways and adaptive feedback, the study did not measure which specific AI features had the greatest impact on learning outcomes. A more detailed investigation into the interaction between learners and AI tools would provide insights for optimizing design (Li et al. 2025; Della Ventura and Zhan n.d.; X. Wang et al. 2021).

Tutor facilitation also played a role during the intervention, as tutors supported learners' use of the e-module and helped troubleshoot difficulties. This suggests that AI serves as a complement rather than a replacement for human guidance in nonformal learning contexts, which should be considered in future implementations.

Motivational factors, including the novelty effect of using AI technology, may have temporarily boosted learner engagement and performance. Future studies should incorporate control groups or longitudinal designs to distinguish sustained learning gains from short-term enthusiasm.

In conclusion, this study supports the feasibility and potential of AI-based e-modules to improve ICT learning in nonformal adult education, but also highlights the need for longer interventions, more nuanced analysis of learner differences, and clearer identification of effective AI features. These insights can guide the refinement of AI-supported learning tools to better serve diverse adult learners in nonformal contexts.

Conclusions

The findings of this study demonstrate that the AI-based e-module is an effective and practical tool for improving ICT learning outcomes and engagement among adult learners in nonformal education settings, particularly within the Package B equivalency program. By integrating adaptive feedback, interactive content, and personalized learning pathways, the module addresses key challenges related to learner motivation, autonomy, and contextual relevance, which traditional materials often overlook. This research contributes original empirical evidence to the limited field of AI-supported instructional media in nonformal education and highlights the potential of such innovations to enhance digital literacy and lifelong learning. While further refinement and longer-term implementation are needed to maximize learning gains, this study provides a valuable framework for developing learner-centered AI tools that can be adapted to diverse adult learning contexts, supporting broader educational equity and inclusion goals.

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