

Development and Evaluation of an AI-Powered E-Module for Microsoft Excel Instruction in Indonesian Vocational Schools

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ABSTRACT

As digital competence becomes essential in the modern workplace, vocational students must master tools like Microsoft Excel. However, traditional instruction in Indonesian vocational schools often lacks adaptability and interactivity. This study aimed to develop and evaluate an AI-powered e-module to enhance students' Excel skills through adaptive learning. Using the ADDIE development model, an AI-integrated e-module was designed and implemented in four vocational schools across Yogyakarta, Central Java, and West Java. The study involved 144 students from the Office Management and Business Services program, divided into experimental and control groups. Data were collected through expert validation, pre- and post-tests, usability questionnaires, and observations. Quantitative analysis included t-tests, N-Gain calculation, and validation of reliability using Cronbach's Alpha. Expert evaluations rated the module as highly feasible (scores $\geq 85\%$). Students in the experimental group showed significantly greater learning gains (N-Gain = 0.65, medium-high category) compared to the control group (N-Gain = 0.42). T-test results confirmed a significant difference ($t(142) = 4.72, p < .001, d = 0.78$). Students also reported improved motivation, confidence, and learning autonomy, while teachers observed reduced need for procedural guidance. The findings demonstrate that AI-powered modules can significantly enhance technical skills in vocational education by offering personalized feedback and adaptive content. The module supports self-directed learning and aligns with the Merdeka Belajar initiative. This study contributes a scalable instructional model for integrating AI into skill-based learning environments.

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1. INTRODUCTION

In the current era, In the past decade, artificial intelligence (AI) has played a transformative role in education by enabling personalized learning environments that adapt to individual student needs. These systems utilize student data to tailor instructional paths, allowing learners to progress at their own pace and style, thereby increasing engagement and mastery (Katiyar et al., 2024). Through

machine learning and analytics, AI-driven platforms now offer real-time feedback, automated recommendations, and intelligent tutoring, marking a fundamental shift in instructional design (Jiao, 2024). This trend reflects the global shift toward data-informed, adaptive learning ecosystems that respond dynamically to learner behavior.

In vocational education, particularly in office administration programs, the demand for digital proficiency especially in Microsoft Excel is sharply rising due to automation and data-driven business operations. However, teaching approaches in many vocational schools remain conventional, with limited digital adaptation and little room for personalization (Silva et al., 2024). The static nature of these traditional methods fails to equip students with real-world, industry-relevant technical competencies. This mismatch between instructional practices and industry expectations continues to weaken vocational graduates' competitiveness in the labor market.

Adaptive learning technologies are increasingly recognized as powerful tools for closing this instructional gap. By dynamically adjusting content and assessment based on student progress, AI-powered platforms not only improve learning outcomes but also enhance student satisfaction (Jian, 2023). These platforms further help instructors identify learning bottlenecks, allowing for targeted interventions and optimized teaching strategies (Alamsyah & Neal, 2025). Despite these benefits, their adoption in vocational settings particularly for spreadsheet software mastery remains limited and inconsistent.

This study introduces an innovative AI-based e-module specifically designed to enhance Microsoft Excel skills among vocational students in the Office Management and Business Services (MPLB) program. The instructional system leverages AI features such as predictive analytics and content adaptation to create a flexible, engaging, and data-informed learning experience (Mai & Li, 2024). This design reflects a shift from linear, one-size-fits-all modules to intelligent instructional ecosystems. Unlike conventional digital modules, this system integrates continuous data tracking, adaptive feedback loops, and dynamic instructional pathways that adjust to learners' performance in real time.

While numerous studies have explored AI in higher education or language learning, few have investigated its application in vocational contexts, especially for spreadsheet software mastery. The majority of previous interventions have concentrated on either general digital literacy or theory-based knowledge, without addressing skill-based learning environments (Castro et al., 2024). More importantly, existing AI-driven learning tools commonly provide static content, lack real-time analytics, and do not modify instructional difficulty based on learner progress, making them less suitable for practical, task-oriented vocational training. This lack of specificity limits their applicability to real-world vocational training.

The motivation for conducting this study emerged from observed deficiencies in Indonesian vocational students' practical skills in using Microsoft Excel, particularly in tasks such as data tabulation, formula application, and basic automation. Preliminary surveys in several vocational schools indicated a noticeable discrepancy between students' perceived competence and their actual performance in completing spreadsheet-based tasks. Many students expressed confidence in their digital abilities, yet assessments revealed difficulties in applying essential Excel functions accurately and efficiently. This mismatch between perceived and actual competence suggests that traditional instructional approaches may not sufficiently support the development of applied digital skills required in vocational education (Hasibuan & Azizah, 2023). Consequently, there is an urgent need for instructional innovations that not only assess learners' abilities but also adapt to individual learning needs and provide responsive guidance throughout the learning process.

One promising approach is the integration of artificial intelligence into digital learning modules. Unlike conventional e-learning materials that typically present static content, AI-based instructional systems can monitor learner interactions and adjust instructional pathways in real time. In many existing digital learning platforms, instructional materials are delivered uniformly to all learners regardless of their learning pace, prior knowledge, or specific difficulties, which can limit the

effectiveness of skill acquisition (Shete et al., 2024). The AI-based e-module developed in this study incorporates adaptive learning features that track students' responses, analyze performance patterns, and provide customized feedback and scaffolded learning materials. Through this feedback loop, learner interactions directly influence the instructional process, allowing the system to guide students toward more effective problem-solving strategies while promoting greater learner autonomy.

Although adaptive learning technologies have gained increasing attention in global educational research, their implementation in vocational education—particularly in Southeast Asian contexts—remains relatively limited. Most studies on adaptive learning systems have focused on general academic subjects rather than vocational skill development, leaving a gap in research related to technical competencies such as spreadsheet processing and digital data management (Wang et al., 2024). This study addresses that gap by developing and evaluating an adaptive instructional system specifically designed for Microsoft Excel training in vocational education. By situating the research within Indonesian vocational schools, the study also contributes regionally relevant empirical evidence on the integration of artificial intelligence in skill-based learning environments.

The primary objective of this research is therefore to evaluate the effectiveness of the developed AI-based e-module in improving vocational students' competence in Microsoft Excel. The evaluation focuses on measuring students' learning outcomes through quantitative assessments, analyzing usability and user experience, and comparing performance differences between experimental and control groups. Through these analyses, the study aims to determine whether adaptive learning mechanisms embedded within the e-module can significantly enhance students' ability to perform essential spreadsheet operations and apply Excel functions in practical tasks.

The urgency of this research is closely related to the growing demand for digital competence in modern labor markets. Vocational graduates are expected to possess practical technological skills that enable them to adapt to rapidly evolving workplace environments. However, when vocational students graduate without adequate proficiency in widely used digital tools such as Microsoft Excel, they may face difficulties competing in increasingly technology-driven industries. The absence of adaptive learning systems in vocational education can further widen the gap between educational outcomes and labor market demands, potentially contributing to digital inequality among graduates (Jian, 2023). Addressing this challenge requires innovative instructional approaches that integrate technological tools with pedagogical strategies designed to support skill mastery.

In this context, the present study offers both theoretical and practical contributions to vocational education and digital learning research. By embedding adaptive artificial intelligence mechanisms into skill-based instruction, the study supports Indonesia's educational reform initiatives, including the "Merdeka Belajar" policy, which emphasizes learner-centered and technology-integrated learning environments. The proposed e-module demonstrates how adaptive digital systems can be used to personalize learning experiences, support students' independent practice, and improve their technical competence in spreadsheet applications. Moreover, the findings provide a scalable and contextually relevant framework that can inform the development of future vocational curricula and digital training programs.

Overall, this research contributes to the growing body of literature on adaptive learning technologies by demonstrating their application in vocational skill training. The AI-based e-module developed in this study provides a replicable instructional model that integrates artificial intelligence with practical digital skill development (Mote, 2024). By aligning pedagogical innovation with technological advancement, the study highlights the potential of adaptive learning systems to enhance vocational education and better prepare students for the demands of the digital workforce.

2. METHODS

This study adopted a Research and Development (R&D) methodology to create an AI-based e-module aimed at enhancing vocational students' competencies in Microsoft Excel. The development

process was structured using the ADDIE instructional design model, comprising the phases of Analyze, Design, Develop, Implement, and Evaluate. The ADDIE model was selected for its widespread use in technology-enhanced learning and its flexibility for iterative design projects (Abuhassna et al., 2024). Previous literature affirms that the ADDIE model effectively supports systematic e-learning development in various educational contexts (Szabo, 2022).

The research was conducted across four vocational high schools (SMK) located in the Yogyakarta Special Region, Central Java, and West Java, Indonesia. The population consisted of approximately 750 students enrolled in the Office Management and Business Services (MPLB) program. Using purposive sampling, 144 students were selected as research participants based on their access to digital devices and prior knowledge of Microsoft Excel. This purposive sampling approach was applied to ensure participant readiness for digital learning; however, it may introduce selection bias because only schools with sufficient digital infrastructure were included. These students were evenly assigned into an experimental group and a control group, each with 72 students. The experimental group received instruction using the AI-based e-module, while the control group used conventional learning methods. The study was carried out over eight months, from October 2024 to May 2025, covering all phases of the ADDIE model and two stages of field implementation.

In the analysis phase, student needs were assessed through interviews, observations, and questionnaires administered in the selected schools. Findings highlighted a significant discrepancy between students' perceived digital proficiency and their actual performance in Excel-based data processing. These results reinforced the need for an adaptive learning solution aligned with students' actual capabilities (Morales González, 2022). The needs analysis also helped identify core competency gaps, which later informed the construction of pre-test and post-test items.

The design phase employed the Modified Delphi Technique to gather expert consensus on learning outcomes, instructional strategies, and media design. This method allowed for structured refinement through multiple feedback loops from subject-matter experts. The Delphi method has been proven effective for instructional content validation and consensus-building in e-learning development (Johnson & Solberg, 2023).

In the development phase, an interactive e-module was created using Canva integrated with Excel's AI-powered features, including Ideas, AutoComplete, and Macro scripting. Flash Fill was incorporated into Task 3 to strengthen pattern recognition skills, where students were required to generate structured outputs from semi-structured datasets. The Ideas feature was embedded in data visualization activities to help students receive AI-generated chart recommendations and trend summaries. AutoComplete supported repetitive formula tasks in which students practiced efficiency-based Excel operations. Macro scripting was introduced in advanced modules where learners developed automated workflows, reinforcing procedural thinking and digital automation competencies. These tools were embedded to personalize user experiences and foster independent data analysis skills. Adaptive instructional systems using AI have been shown to improve skill acquisition and learner autonomy (Yu et al., 2025).

Implementation was conducted in two stages. A Small Group Trial was carried out with 30 students and 3 teachers to assess usability and engagement. Feedback led to revisions in navigational flow, media clarity, and interaction features. Subsequently, a Large-Scale Field Test was conducted with the full sample of 144 students. The use of comparative groups in adaptive learning studies is supported by established research practices (Shete et al., 2024).

Quantitative data were gathered via pre-test and post-test assessments. The pre-test and post-test consisted of 25 items covering four domains: (1) data entry and formatting, (2) formula and function application (SUM, AVERAGE, IF, VLOOKUP), (3) data analysis using PivotTables, and (4) automation tasks involving Flash Fill and basic Macros. Each domain was mapped to MPLB competency standards to ensure content validity. The data were analyzed for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. When data did not meet parametric assumptions, Wilcoxon Signed-Rank and Mann-Whitney U tests were applied. These non-parametric techniques are commonly used in

educational intervention research when assumptions of normality are not met (Jian, 2023). For parametric data, Paired t-tests and Independent t-tests were employed to measure within- and between-group differences.

The N-Gain Score was calculated to determine relative learning improvements. Results showed a significantly higher gain in the experimental group, confirming the module’s effectiveness. Similar AI-driven instructional systems have demonstrated significant learning improvements in both conceptual and skill-based domains (Silva et al., 2024).

Usability and feasibility were validated by three instructional design experts, three teachers, and 144 student participants. Experts rated the module on content accuracy, media interactivity, and alignment with learning outcomes, with all scores exceeding 83%. Instrument reliability was assessed using Cronbach’s Alpha, yielding $\alpha = 0.87$ for the student perception questionnaire and $\alpha = 0.91$ for the usability scale, indicating high internal consistency. Usability research suggests that such validation contributes to module refinement and adoption scalability.

All research activities complied with ethical standards. Informed consent was obtained from participants, and data privacy was preserved throughout the study. The development and testing were conducted over an eight-month period, ensuring adequate time for iterative design and empirical evaluation

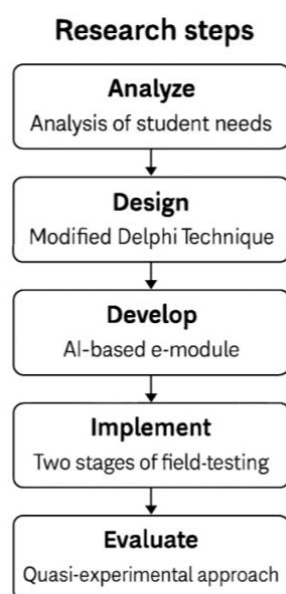


Figure 1. Research steps

3. FINDINGS AND DISCUSSION

3.1 Product Validation and Small-Scale Trial Results

The AI-based e-module underwent expert validation from three evaluators: a subject matter expert, a media expert, and a vocational teacher. Validation focused on accuracy, clarity, usability, and integration of AI features. To present the data concisely, expert validation scores are summarized in Table 1.

Table 1. Expert Validation Scores

Evaluator	Score (%)	Category
Subject Matter Expert	87.5	Very Feasible
Media Expert	91.7	Very Feasible
Vocational Teacher	85.4	Feasible

A small-scale trial with 30 students and 3 teachers demonstrated high usability and engagement, with 86.7% of students reporting ease of use and 83.3% acknowledging that AI tools such as Ideas and Flash Fill improved task efficiency. Qualitative feedback highlighted the need for clearer instructions on AI feature usage; revisions were subsequently made.

3.2 Large-Scale Field Test and Student Learning Outcomes

Pre-test data indicated no significant differences between experimental and control groups, confirming baseline equivalence. Following four weeks of learning, the experimental group demonstrated significantly higher post-test scores.

Table 2. Pretest–Posttest Comparison and N-Gain Scores

Group	Pre-test Mean	Post-test Mean	N-Gain	Category
Experimental (n=72)	58.21	82.4	0.65	Medium–High
Control (n=72)	57.89	73.1	0.42	Medium

The difference was statistically significant, $t(142) = 4.72$, $p < .001$, $d = 0.78$, indicating a large effect size in favor of the experimental group. These findings align with research showing that AI-powered instructional systems enhance feedback quality and learning efficiency in vocational education

Table 3. Student Perception Summary

Statement	Agree (%)
AI helped me understand Excel	89
The module increased my motivation	91

Teacher observations reinforced that AI-supported students demonstrated greater autonomy and confidence. Challenges included unstable connectivity and initial unfamiliarity with AI features, consistent with national-level findings on digital readiness (Nazla, 2025).

Discussion

The findings of this study demonstrate that the AI-based e-module significantly improved vocational students' mastery of Microsoft Excel compared to conventional instructional approaches. The experimental group achieved substantially higher post-test scores than the control group, indicating that the integration of adaptive AI features—such as Ideas, Flash Fill, and AutoComplete—supported students in understanding spreadsheet functions and data-processing tasks more efficiently. These intelligent features allowed learners to identify patterns, automate repetitive procedures, and

receive system-generated suggestions, thereby accelerating their learning process. The results are consistent with research indicating that AI-supported personalized learning environments enhance student engagement and facilitate deeper mastery of digital skills by tailoring instructional support to individual learning needs (Bhattacharya & Nakhare, 2019).

The validity and quality of the developed module were further confirmed through expert validation results. Scores exceeding 85 percent across material, media, and vocational teaching aspects suggest that the module met essential standards of instructional design, including accuracy of content, usability of interface, and relevance to vocational learning outcomes. High validation ratings indicate that the module provides coherent learning materials aligned with competency-based vocational curricula. These findings correspond with previous studies emphasizing that rigorous validation is a critical step in ensuring the effectiveness and credibility of digital learning tools prior to their implementation in educational settings (Febriani et al., 2024; Anugrah, 2021).

Results from the small-scale trial further illustrate the practicality of the AI-based module in classroom settings. Students were able to navigate the e-module independently and complete most tasks with minimal assistance from teachers. The interactive interface and guided features allowed learners to explore spreadsheet functions through structured activities, reducing the need for continuous instructor guidance. Similar findings were reported by Arif et al. (2019), who found that interactive digital modules can enhance learner autonomy and engagement in vocational learning environments. In the present study, AI-powered functions such as Flash Fill and Ideas enabled students to recognize logical patterns within spreadsheet data and correct mistakes during task completion. This capability helped reduce the cognitive load typically experienced when learners encounter complex procedural tasks, allowing students to focus more on conceptual understanding rather than repetitive technical steps (Kurnaedi & Widyarto, 2024).

Observations conducted by teachers during the trial phase revealed a notable shift in classroom instructional dynamics. Compared with traditional instruction, students required fewer procedural explanations and demonstrated greater independence when solving spreadsheet-related problems. The AI components embedded within the module effectively functioned as automated scaffolding systems that provided real-time feedback and suggestions. Immediate machine-assisted responses allowed students to identify and correct errors as they occurred, minimizing misconceptions during the learning process. This phenomenon reflects broader trends in AI-enhanced education, where intelligent systems increasingly support formative feedback and adaptive instruction (Nisyah et al., 2022).

The large-scale field test further confirmed the effectiveness of the AI-based e-module in improving students' learning outcomes. The experimental group achieved an N-Gain score of 0.65, categorized as medium-to-high improvement, indicating a substantial increase in Excel competency compared with their initial performance levels. In contrast, the control group obtained an N-Gain score of 0.42, suggesting moderate improvement under traditional instructional conditions. The difference between these scores suggests that adaptive AI-based learning environments can provide more meaningful and differentiated learning experiences for vocational students. These findings are consistent with previous research demonstrating that adaptive technologies improve learning outcomes by dynamically responding to students' performance and providing targeted instructional support (Hidayat et al., 2020; Yu et al., 2025).

Student perception data also reinforced the quantitative findings regarding the effectiveness of the module. A large majority of participants reported that the AI-supported features helped them understand Excel tasks more easily and increased their motivation during learning activities. Students particularly appreciated the automated suggestions and pattern-recognition tools, which enabled them to complete assignments more efficiently and with greater confidence. These results align with studies indicating that interactive digital learning environments enhance student engagement, particularly in vocational education contexts where learning activities emphasize practical and task-oriented skills (Karim et al., 2025; Maksum et al., 2025). Increased engagement may also explain the improved learning

outcomes observed in the experimental group, as motivation plays an important role in sustaining learners' effort during technical training.

Beyond improvements in academic performance, the intervention also influenced students' behavioral patterns during the learning process. Learners in the experimental group displayed higher levels of confidence and independence while practicing Excel tasks, often attempting solutions before seeking teacher assistance. This shift toward self-directed learning reflects the capacity of AI-supported instructional systems to empower learners and reduce dependence on teacher-centered guidance. Similar conclusions were reported by Nuh et al. (2025), who observed that AI-integrated learning platforms encourage learners to explore digital tools independently. Intelligent tutoring systems have also been shown to promote learner autonomy by providing structured guidance without removing the learner's responsibility for problem solving (Zary & Zary, 2025).

Another significant finding relates to the reduction of discrepancies between students' perceived and actual digital competencies. Initial assessments revealed that many vocational students believed they possessed adequate Excel skills despite demonstrating limited proficiency in practical tasks. This overestimation of digital competence has been widely documented among vocational learners in Indonesia (Maulana et al., 2021). Through structured AI-supported learning activities, students were exposed to progressively challenging tasks that revealed gaps in their understanding while simultaneously guiding them toward correct procedures. As students practiced using the adaptive features of the module, their performance improved substantially, suggesting that AI-assisted instruction can help align students' self-perception with their actual skill levels.

Although the implementation of the module produced positive outcomes, several practical challenges were identified during the study. Some students initially experienced difficulties related to unstable internet connectivity and unfamiliarity with AI-assisted spreadsheet features. These challenges, however, did not significantly reduce the overall effectiveness of the intervention. Embedded tutorials, guided prompts, and step-by-step instructions helped students gradually adapt to the new learning environment. Research by Chen (2025) suggests that well-designed onboarding features can ease the transition into AI-supported learning systems. Furthermore, technology adoption in educational contexts is often influenced by infrastructure conditions and digital readiness, highlighting the importance of adaptable system design that can function effectively even in less-than-optimal technological environments (Nazla, 2025).

Overall, the results of this study indicate that the AI-based e-module represents an effective and contextually relevant instructional innovation for vocational education. The module not only improved students' technical competence in Microsoft Excel but also strengthened learner engagement, confidence, and autonomy during the learning process. These outcomes highlight the potential of adaptive AI systems to modernize vocational training and align educational practices with the evolving demands of the digital workforce and Industry 4.0. By integrating intelligent features that respond to learner performance patterns, the module demonstrates how digital technologies can support more personalized, efficient, and scalable approaches to vocational skill development.

4. CONCLUSION

This study demonstrates that the AI-based e-module significantly improved vocational students' mastery of Microsoft Excel, as indicated by higher post-test scores, stronger N-Gain values, and positive student perceptions of the learning experience. The adaptive features embedded in the module—including automated insights, pattern recognition, and real-time feedback—enabled more personalized learning processes and supported greater student independence when completing spreadsheet tasks. Compared with traditional instructional approaches, the AI-supported module provided a more responsive and engaging learning environment that helped students understand complex Excel functions more effectively. These findings highlight the potential of AI-driven instructional tools to enhance digital competence among vocational students and support educational reforms aimed at

strengthening technology-based learning within Indonesia's vocational education system. Despite these promising outcomes, the study has several limitations, including the relatively limited sample drawn from schools with adequate digital infrastructure and the short duration of the intervention, which focused primarily on immediate learning gains rather than long-term skill retention. Therefore, future research should investigate the sustainability and transferability of AI-supported skills over longer periods and in authentic workplace contexts where Excel proficiency is required. Further studies are also recommended to explore the effectiveness of similar AI-based modules across schools with varying technological resources and to examine the role of teachers' AI readiness in influencing successful implementation, thereby identifying the conditions necessary for the sustainable and equitable adoption of AI-supported learning in vocational education.

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