

AI-Based Learning Modules to Enhance Students' Entrepreneurial Intentions

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Abstract

Artificial intelligence (AI) is widely recognized as a transformative technology with substantial potential to enhance education, especially in entrepreneurship learning. However, entrepreneurship education, especially in secondary education, appears to be theoretical, with no real AI-supported learning approaches in practice. This study aimed to develop an AI-based entrepreneurship learning module and then evaluate its effectiveness for improving students' entrepreneurial intentions. This study followed a Research and Development (R&D) approach with the ADDIE model: analysis, design, development, implementation, and evaluation. It involved students from a private high school and a public vocational school in Bandar Lampung, Indonesia. Data were collected through interviews, questionnaires, expert validation, pretests, posttests, and N-Gain analysis. The results showed that the developed module was valid, feasible, and highly effective in improving students' entrepreneurial intentions. A significant difference was found between students' pretest and posttest scores, supported by high N-Gain scores and a very large effect size. The student participants also responded positively to the AI-supported learning features. This study contributes to the growing literature on AI-enhanced entrepreneurship education by providing empirical evidence from secondary education contexts, particularly in developing countries. The implications and suggestions for future research are also highlighted.

Keywords: *Artificial Intelligence, Entrepreneurial Intentions, Entrepreneurship Learning Innovation, Learning Modules.*

Introduction

Entrepreneurship education has become a strategic global agenda in response to the challenges of unemployment, technological disruption, and the rapidly changing labor market in the era of digital transformation. In many countries, educational institutions are increasingly expected not only to prepare students to be job seekers but also to equip them with entrepreneurial competencies that enable them to become job creators and innovators. This issue is even more pressing in developing countries, including Indonesia, where the demographic dividend has intensified competition in the labor market and increased the number of unemployed educated youth. According to the Central Statistics Agency (BPS, 2024), the national open unemployment rate reached 5.32%, equivalent

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to approximately 7.86 million unemployed people. Vocational high school (SMK) graduates had the highest unemployment rate, at 9.31%, followed by senior high school (SMA) graduates at 8.15%. These figures suggest that secondary institutions have not yet succeeded in preparing graduates who are adaptive, innovative, and capable of creating independent economic opportunities.

Several studies have identified multiple factors contributing to the high unemployment rate among school graduates. Cultural orientation remains one of the primary barriers, where employment in established institutions is still perceived as a more prestigious career path than entrepreneurship (Stanley, 2016; Sugiartiningsih et al., 2019). Furthermore, formal education has often been criticized for failing to produce graduates ready to face real-world economic and industrial challenges (Atiqah et al., 2025; Indiantoro, 2017; Nur'aini et al., 2019). Previous studies further reported a mismatch between graduates' competencies and labor market demands, particularly regarding creativity, innovation, adaptability, and entrepreneurial skills (Ariansyah et al., 2023; 2024; Rachmawati et al., 2024). Although vocational education aims to prepare students with practical skills, its implementation remains largely oriented toward producing workers rather than entrepreneurs (Harianto et al., 2025; Sudiyono et al., 2024). Consequently, graduates become increasingly vulnerable to unemployment when employment opportunities are limited.

In response to these challenges, entrepreneurship education has gained significant attention as an effective strategy to foster entrepreneurial intentions among students. Entrepreneurship learning, particularly through Craft and Entrepreneurship Education (PKWU), is expected to develop students' creativity, innovation, problem-solving skills, and business awareness (Boahemaah et al., 2020; Widodo et al., 2025). Previous research conducted in various countries has demonstrated that entrepreneurship education positively influences students' entrepreneurial intentions, self-efficacy, and business motivation (Oktavian et al., 2023; Shofwan et al., 2023; Uma & Anasrulloh, 2023). Studies in Finland, China, South Korea, and Malaysia have also shown that experiential and technology-supported entrepreneurship learning environments can significantly enhance students' entrepreneurial mindsets and engagement. However, despite the growing integration of digital technologies in education, entrepreneurship learning in many secondary schools still relies on conventional, theory-oriented approaches (Abadiyah et al., 2025; Anggadwita et al., 2016). Few

schools draw on AI to provide students with interactive practice or personalized learning experiences. AI has substantial potential to reshape educational practices worldwide.

AI-based learning environments can provide adaptive feedback, personalized learning pathways, intelligent tutoring, real-time simulation, and interactive decision-making experiences that may strengthen students' entrepreneurial competencies. Several recent studies have explored the integration of AI in higher education, particularly in business education, digital entrepreneurship, and entrepreneurial analytics (Mlambo et al., 2023; Marais, 2023). For example, studies in the United States, China, and Singapore reported that AI-supported learning systems could improve students' critical thinking, creativity, and entrepreneurial problem-solving abilities (Guo et al., 2026). Nevertheless, the implementation of AI-based entrepreneurship learning modules at the secondary school level remains extremely limited. Previous studies predominantly focus on university students, digital business training, or general AI-assisted learning systems, rather than on structured AI-based entrepreneurship modules specifically designed for high school or vocational school students. This gap in the literature suggests that research on AI has not placed a strong focus on secondary education, particularly in entrepreneurship learning.

Therefore, this study aimed to develop an AI-based learning module and evaluate its effectiveness in improving students' entrepreneurial intentions and academic achievement in high school and vocational school contexts. More specifically, this study was guided by the following research questions:

1. How effective is the AI-based entrepreneurship learning module in improving students' entrepreneurial intentions?
2. How significant is the practical impact of the AI-based learning module on students' entrepreneurial intentions?

Based on these research questions, this study proposed the following hypotheses:

- H1: The AI-based entrepreneurship learning module significantly improves students' entrepreneurial intentions.
- H2: There is a significant practical impact of the AI-based learning module on students' entrepreneurial intentions.

Literature Review

To situate the present study, the following sections review three relevant strands of literature: (1) artificial intelligence in education, (2) learning modules, and (3) entrepreneurship education.

Artificial Intelligence

AI has become one of the most transformative technologies of the 21st century, significantly influencing sectors such as education, business, and entrepreneurship. AI is a branch of computer science concerned with developing intelligent systems capable of performing tasks that typically require human cognitive abilities, such as learning, reasoning, problem-solving, and decision-making (Jatmika et al., 2024; Santos et al., 2025). McCarthy (2007) defined AI as the science and engineering of producing intelligent machines, particularly computer programs capable of simulating human thinking processes. Specifically, AI systems are designed not only to process information efficiently but also to adapt, learn from experience, and provide recommendations based on data-driven analysis (Obschonka & Audretsch, 2020; Tan et al., 2025). The primary objective of AI development is to create systems that can perform complex tasks intelligently, support human decision-making, and enhance the effectiveness of problem-solving processes across various domains.

In recent years, AI has increasingly been integrated into educational contexts due to its potential to create more adaptive, interactive, and personalized learning environments (Phuengrod et al., 2026). Within entrepreneurship education, AI technologies offer substantial opportunities to improve students' entrepreneurial competencies and learning experiences. Previous studies have shown that AI can support entrepreneurship learning through various applications, including business idea generation, market trend prediction, data-driven decision-making, business process automation, and customer behavior analysis (Kravets et al., 2025; Amin et al., 2025). Furthermore, AI-driven educational technologies, such as adaptive learning systems, intelligent tutoring systems, predictive analytics, and simulation-based learning, enable educators to provide learning experiences that are more responsive to students' individual needs and entrepreneurial learning objectives (Dunan et al., 2025; Zhang, 2025).

Moreover, the integration of AI into entrepreneurship education has been reported to enhance students' engagement, creativity, critical thinking, and innovation capabilities, which are

considered essential competencies for entrepreneurial success in the digital economy (Yu et al., 2025). In particular, generative AI technologies can stimulate students' creative problem-solving abilities by facilitating idea exploration, business model development, and scenario-based learning activities (Somia & Vecchiarini, 2024). Creative problem-solving, idea exploration, and scenario-based learning are particularly relevant in entrepreneurship education, where innovation and opportunity recognition play a central role in entrepreneurial development. Consequently, the incorporation of AI into entrepreneurship education not only supports knowledge acquisition but also fosters entrepreneurial mindsets and future-oriented competencies required in contemporary business environments.

Learning Module

Learning modules play a significant role in supporting effective instruction by facilitating students' understanding and retention of learning materials. In educational contexts, modules are commonly designed as structured teaching resources that enable students to learn independently, systematically, and at their own pace (Arroz, 2024). As instructional tools, learning modules not only provide organized learning content but also help students access relevant information during both classroom and self-directed learning activities. Consequently, the use of well-designed modules can improve students' engagement, comprehension, and overall learning performance. Previous studies have also reported that module-based learning contributes positively to students' motivation, conceptual understanding, and learning autonomy, particularly in technology-supported educational environments (Hidayati et al., 2023; Wulandari & Rahmawati, 2022).

In recent years, the development of learning modules has evolved alongside advances in educational technology. Contemporary learning modules increasingly integrate digital technologies and interactive features to create more adaptive, student-centered learning environments. These learning modules represent an innovative instructional management approach that combines learning materials, pedagogical strategies, and technological support to optimize students' learning potential (Sirisuthi & Chantarasombat, 2021). Integrating digital and interactive features into modules makes learning activities more flexible, interactive, and responsive to students' needs, particularly in supporting independent and experiential learning. In addition, technology-supported modules can facilitate active learning by encouraging students to explore content, solve problems, and engage in reflective thinking activities more effectively.

Several recent studies further indicated that digital and AI-assisted learning modules can improve students' critical thinking, collaboration, and engagement in entrepreneurship and social science learning contexts (Zhang, 2025).

The effectiveness of learning modules largely depends on their relevance to students' characteristics, learning objectives, and classroom contexts. Therefore, teachers are required to adapt instructional materials and module content to specific educational settings and students' learning needs. Contextualized modules are considered more effective because they allow students to connect theoretical concepts with real-life situations and practical experiences (Pratama et al., 2023). In entrepreneurship education, for example, learning modules should not merely focus on theoretical knowledge but also on fostering creativity, innovation, decision-making, and problem-solving skills essential for entrepreneurial development (Hasan et al., 2024; Widodo et al., 2025). Accordingly, integrating technology-enhanced learning modules into entrepreneurship education can provide meaningful learning experiences that strengthen students' motivation, participation, and entrepreneurial competencies. Integrating technology-enhanced modules into entrepreneurship education is increasingly important in contemporary education, where instructional innovation is needed to prepare students for rapidly changing social and economic environments (Dunan et al., 2025; Yu et al., 2025).

Entrepreneurship Education

Entrepreneurship education has increasingly been recognized as a strategic approach to preparing individuals for the demands of contemporary economic and labor market environments. Entrepreneurship education, in a broad sense, refers to the process of developing individuals' ability to transform innovative ideas into viable business ventures or to expand and diversify existing enterprises with sustainable growth potential (Adeel et al., 2023; Ndlovu, 2024). In recent decades, entrepreneurship education programs have been widely implemented across elementary, secondary, and higher education levels as part of broader efforts to address unemployment, stimulate economic development, and strengthen local communities. Both public and private institutions have adopted entrepreneurship education initiatives in various forms, ranging from formal classroom instruction to experiential learning programs and technology-supported entrepreneurial training (Ganefri et al., 2024; Mion et al., 2026). The widespread adoption of entrepreneurship education programs reflects the growing recognition that entrepreneurship is not

only an economic activity but also an essential competency for navigating the uncertainties of the modern world.

Furthermore, entrepreneurship education extends beyond the acquisition of business-related knowledge and technical competencies. Previous studies have emphasized that effective entrepreneurship education also contributes to the development of non-technical, or soft, skills, including creativity, innovation, opportunity recognition, problem-solving, critical thinking, adaptability, and risk-taking (Liang et al., 2025). These competencies are considered fundamental for individuals seeking to succeed in highly competitive and rapidly changing economic environments. In educational contexts, entrepreneurship learning activities are increasingly designed to encourage students to think independently, identify opportunities, and develop innovative solutions to real-world problems. As a result, entrepreneurship education is viewed as an important mechanism for fostering entrepreneurial mindsets and preparing students to become proactive contributors to economic and social development.

Empirical evidence has consistently demonstrated the positive contribution of entrepreneurship education to students' entrepreneurial intentions, competencies, and entrepreneurial behaviors. Previous studies reported that entrepreneurship education significantly enhances students' confidence, entrepreneurial self-efficacy, and willingness to pursue entrepreneurship as a future career pathway, particularly among secondary school and vocational education students (Audu, 2022). Moreover, entrepreneurship education has been associated with broader socioeconomic benefits, including job creation, economic resilience, and sustainable community development. In this regard, Tchokoté and Bawack (2024) argued that entrepreneurship education plays a crucial role in equipping individuals with the entrepreneurial mindsets, attitudes, and competencies necessary to respond effectively to complex, evolving entrepreneurial ecosystems. Therefore, strengthening entrepreneurship education within formal educational institutions has become increasingly important to prepare students for participation in dynamic economic environments shaped by globalization, digital transformation, and technological innovation (Du Toit, 2023; Sekerbayeva et al., 2023).

Method

Research Design

This study followed a research and development (R&D) methodology, more specifically the ADDIE model (Dick & Carey, 1996), consisting of five stages: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. The ADDIE model was selected because its steps are concise, straightforward, and appropriate to the characteristics of the research location. Figure 1 shows the stages of this study guided by the ADDIE model, and Table 1 provides details for each stage of development.

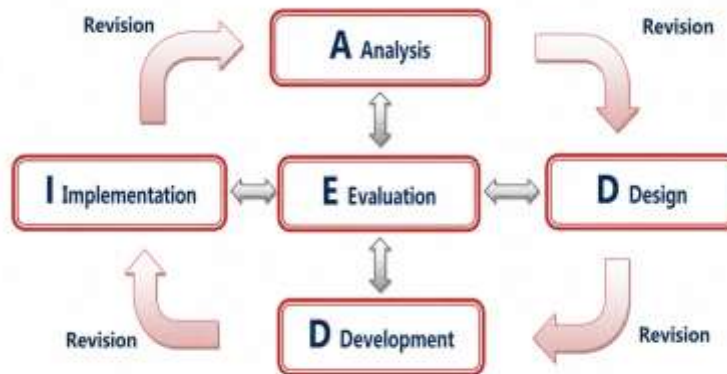


Figure 1. Stages of the ADDIE Development Model

Table 1

Details of Research Stages

Main Phase	Key Activities	Focus & Concrete Actions
Analysis	Identifying Needs & Problems	- Analyzing the gap between current student abilities and expected competencies. - Identifying student characteristics, learning environments, and learning objectives.
Design	Strategy and Product Planning	- Developing specific and measurable learning objectives. - Selecting appropriate delivery strategies, methods, and learning media. - Creating a blueprint, such as a sequence of materials and a storyboard.

Development	Material & System Production	• Producing materials or products (e.g., modules, videos, or e-learning applications). • Conducting product validation by experts (materials and media) and initial revisions before testing.
Implementation	Field Implementation	• Implementing learning designs and materials in actual classrooms or target groups. • Ensuring instructors and learners are ready to use new systems or media.
Evaluation	Assessment and Improvement	• Conducting formative (during the process) and summative (at the end) evaluations. • Measuring the level of learning success and collect feedback for continuous improvement.

Background and Research Participants

This study involved students from a private high school and a public vocational school in Bandar Lampung, Indonesia, as participants across several stages of the research and development process. Both schools participated in the needs analysis stage, which identified differences in learning objectives, student characteristics, instructional materials, learning outcomes, and curriculum implementation related to entrepreneurship education. Findings from the needs analysis served as the foundation for designing an AI-based entrepreneurship learning module. The participants comprised 64 students purposively selected for their relevance to the research objectives, all of whom had previously completed introductory entrepreneurship courses. Furthermore, 15 students from the private high school participated in a limited-scale trial to evaluate and refine the initial prototype before broader implementation. Throughout the ADDIE stages, the product evolved systematically from needs analysis and prototype development to validation, implementation, and final revision. The final product was an AI-based entrepreneurship learning module.

Research Instruments and Data Analysis

This study was both qualitative and quantitative. For the quantitative part, it used questionnaires, pretests, and posttests. Two types of questionnaires are the main instruments. The first was a Likert-scale questionnaire assessing media validity, language, and presentation. The second, also a Likert scale, measured practicality and entrepreneurial interest. The quantitative data were analyzed using descriptive statistics, and the qualitative data were collected through interviews,

observations, and expert validation, then analyzed using data reduction, data presentation, and conclusion.

Instrument Validity and Reliability

The validation process was conducted systematically to ensure the methodological quality of both the research instruments and the AI-based entrepreneurship learning module. The data from the questionnaires and the prototype were evaluated by two experts in instructional materials and educational media, followed by several revisions to improve instructional clarity, alignment with AI-based learning objectives, and the indicators of entrepreneurial intention. The reliability testing demonstrated strong internal consistency for the entrepreneurial intention construct (Cronbach's $\alpha = .865$). At the same time, the contextual essay rubric showed high inter-rater reliability (Cohen's Kappa = .83). In addition, the credibility of the qualitative instruments was strengthened through expert validation, triangulation, and member checking before implementation in the limited and large-scale trials.

Findings

Analysis Stage

This analysis stage aimed to examine students' learning needs, entrepreneurial aspirations, and perceptions regarding the effectiveness of existing entrepreneurship learning media. Results showed a clear preference for more interactive, technology-supported learning resources. Their statements suggested that the entrepreneurship modules currently used in schools were predominantly text-based, teacher-centered, and focused on theoretical knowledge, with limited opportunities for business simulations, personalized feedback, or real-world entrepreneurial problem-solving. Classroom observations further revealed that the existing modules lacked interactive digital features and were unable to accommodate differences in students' learning pace, interests, and entrepreneurial readiness. Consequently, students often perceived entrepreneurship learning as less engaging and less relevant to contemporary business practices, particularly those influenced by digital transformation and artificial intelligence.

Despite these limitations, students demonstrated positive entrepreneurial aspirations and attitudes toward entrepreneurship as a future career path. However, these aspirations were not consistently translated into concrete entrepreneurial actions. This finding is reflected in the relatively lower

mean score for the statement “I want to start a small business while still attending school” ($M = 3.3$), indicating that many students lacked entrepreneurial confidence, practical experience, and business planning skills (see Table 2). Interviews further revealed that students were interested in learning experiences that provided practical guidance, immediate feedback, and opportunities to test business ideas in authentic contexts before engaging in actual entrepreneurial activities.

The needs assessment also identified several characteristics required for a new AI-based entrepreneurship learning module. First, students expressed a need for adaptive learning content that could adjust to their individual learning progress and entrepreneurial competencies. Second, they preferred interactive learning activities supported by AI-generated feedback to help them evaluate business ideas and improve decision-making skills. Third, students emphasized the importance of business simulations, case-based learning, and project-based activities that reflected real entrepreneurial challenges. These findings demonstrated that future entrepreneurship learning resources should not only deliver content but also facilitate personalized, experiential, and data-driven learning experiences.

Based on the needs assessment, a blueprint of the AI-based entrepreneurship learning module was formulated as the initial prototype. This blueprint consisted of four integrated components: (1) AI-supported entrepreneurial concept learning, which provided adaptive explanations and personalized learning pathways; (2) AI-powered business idea generation, enabling students to explore and refine entrepreneurial opportunities through guided prompts; (3) business simulation and project-based activities, allowing students to develop and test business plans in realistic scenarios; and (4) AI-driven feedback and learning analytics, providing recommendations for improvement and monitoring students’ entrepreneurial progress. The module was designed to align with the entrepreneurship curriculum while incorporating artificial intelligence to enhance engagement, self-regulated learning, and entrepreneurial intention development. Figure 2 presents the blueprint of the proposed AI-based entrepreneurship learning module developed from the needs analysis stage.



Figure 2. Cover of the AI-Based Entrepreneurship Learning Module Design.

Table 2

Students' Needs Analysis in Entrepreneurship Learning

Statement	Mean Score	Interpretation
I need interactive learning media to understand business concepts	4.1	High
I am interested in owning a business in the future	3.9	High
I want to start a small business while still attending school	3.3	Moderate

The findings from the analysis stage confirmed the need to develop an AI-based entrepreneurship learning module that addressed the limitations of conventional learning resources to supports students' entrepreneurial intentions through adaptive, interactive, and experiential learning environments.

Design Stage

During this stage, a prototype was designed and developed to provide a more adaptive, interactive, and experiential entrepreneurship learning environment. The prototype consisted of four integrated components designed to address the specific needs identified during the analysis stage. The first component was the Young Entrepreneur Learning Module, which contained structured learning materials covering entrepreneurial mindset development, business opportunity recognition, idea generation, business model development, basic financial literacy, and digital entrepreneurship.

Unlike the previous module, the content was organized into self-paced learning units that encouraged independent learning and reflective thinking. Each unit included contextual case studies, project-based activities, and real-life entrepreneurial scenarios to bridge the gap between theoretical understanding and practical application.

The second one was an AI-Based Business Idea Generator, developed in response to students' perceived difficulties in identifying feasible business opportunities. Through guided prompts and interactive questioning, the system helped students generate business ideas based on local resources, personal interests, and market needs. This feature was designed to strengthen students' entrepreneurial creativity and opportunity recognition skills, which were identified as areas requiring support during interviews and classroom observations.

The third component was an Entrepreneurship Simulation Platform, which addressed students' demand for practical entrepreneurial experiences. The platform allowed students to explore virtual entrepreneurial activities such as product selection, market targeting, pricing strategies, promotion planning, and profit estimation. By engaging in simulated business decision-making processes, students could experiment with entrepreneurial strategies in a low-risk environment before applying them in real-world contexts. This feature was intended to enhance entrepreneurial self-efficacy and confidence, which were found to be relatively weak during the needs assessment.

Finally, the fourth aspect was related to an AI-Powered Virtual Entrepreneur Assistant, designed to provide personalized learning support throughout the learning process. This chatbot-based feature enabled students to ask entrepreneurship-related questions, receive instant explanations, obtain recommendations for improving business ideas, and access individualized feedback based on their learning progress. The inclusion of this feature was directly informed by interview findings indicating students' need for continuous guidance beyond classroom interactions. In addition, the system provided learning analytics that allowed teachers to monitor student participation, learning achievements, and entrepreneurial development more efficiently.

The resulting prototype represented a comprehensive integration of entrepreneurship content, artificial intelligence, experiential learning, and personalized feedback mechanisms. The design aimed not only to improve students' understanding of entrepreneurship concepts but also to foster

entrepreneurial confidence, creativity, and intention through active engagement with AI-supported learning experiences.

Development Stage

In this stage of development, the focus was on transforming the validated design blueprint into an operational AI-based entrepreneurship learning module titled "Becoming a Young Entrepreneur for High School Students." This phase included learning content production, integration of artificial intelligence features, expert consultation, prototype revision, and refinement of the final product. The primary objective was to ensure that the module met pedagogical, technological, and entrepreneurship education standards before proceeding to classroom implementation.

Based on the prototype developed during the design phase, the module was built by integrating entrepreneurship learning materials with AI-powered learning tools. The learning materials covered developing an entrepreneurial mindset, recognizing business opportunities, generating ideas, business planning, digital marketing, and basic financial management. In addition, several AI-based components were embedded into the module, including an AI Business Idea Generator, an Entrepreneurship Simulation Platform, and an AI-powered Virtual Entrepreneur Assistant. These features were designed and developed to address the needs identified during the analysis phase, specifically student demand for personalized learning support, practical entrepreneurial experiences, immediate feedback, and an interactive learning environment.

Before implementation, the prototype was submitted to a panel of experts for evaluation and approval. The expert review process involved experts in the field of instructional media and entrepreneurship subject matter experts. The purpose of this consultation was to determine whether the prototype met the minimum quality standards required for classroom implementation and to identify areas for improvement. Media experts evaluated the interface design, visual appearance, readability, navigation, usability, and effectiveness of the AI-integrated features. Meanwhile, subject matter experts assessed content relevance, conceptual accuracy, curriculum alignment, learning coherence, and the appropriateness of learning activities for secondary school students.

The validation results indicated that the prototype achieved a high level of feasibility across all assessed dimensions (see Table 3). Media experts gave an average score of 4.5 for media design

and 4.4 for application functionality, both categorized as "Very Valid." Similarly, subject matter experts rated the content quality at 4.6 and the learning design at 4.5, indicating a "Very Valid" classification. These findings showed that the prototype was pedagogically appropriate, technologically functional, and adequately aligned with the objectives of entrepreneurship learning. Therefore, the experts agreed that the module was worthy of moving to the next stage, subject to several recommended revisions.

Several constructive suggestions emerged from the expert consultation process. First, the media expert recommended improving visual consistency by standardizing icon design, color schemes, and page layouts across modules. The expert also suggested improving navigation features to facilitate easier movement between learning units and AI-powered activities. Second, the expert recommended refining the AI-generated feedback mechanism to provide more specific entrepreneurial recommendations and clearer explanations of business simulation results. Third, the expert suggested strengthening the connection between entrepreneurship concepts and the local business context by including additional case studies from small and medium-sized enterprises. They also recommended simplifying some technical entrepreneurship terms to improve readability for high school students and expanding project-based learning activities to encourage greater student engagement.

Following the expert recommendations, a series of revisions were made to refine the prototype. Visual elements were redesigned to ensure consistency and ease of use, navigation menus were simplified, and AI-generated feedback prompts were refined to provide more personalized learning guidance. Additional local entrepreneurship cases were integrated into the learning materials, while several learning activities were redesigned to better support experiential and project-based learning. Furthermore, the assessment rubric and reflective learning assignments were revised to better align with the expected entrepreneurship competencies and learning outcomes.

After all revisions had been completed, the final prototype underwent a final review to verify that the recommended improvements had been adequately addressed. The experts confirmed that the revised module demonstrated substantial improvements in instructional quality, technological functionality, user experience, and content relevance. Therefore, the AI-based entrepreneurship learning module was declared feasible and ready for small-scale and large-scale implementation

trials. The finalized product served as the basis for evaluating the effectiveness of AI-supported entrepreneurship learning in enhancing students' entrepreneurial intentions. Figure 3 presents the final design prototype of the AI-Based Entrepreneurship Learning Module.



Figure 3. Cover of the AI-Based Entrepreneurship Learning Module

Table 3

Expert Validation Results of the AI-Based Entrepreneurship Learning Module

Validation Aspects	Indicators Assessed	Validator	Mean Score	Interpretation
Media Design	Interface, layout, readability, color composition	Media Experts	4.5	Very Valid
Application Functionality	AI features, usability, navigation	Media Experts	4.4	Very Valid
Material Quality	Content relevance, clarity, accuracy	Material Experts	4.6	Very Valid
Instructional Design	Learning objectives, activities, assessment suitability	Material Experts	4.5	Very Valid

The validation and revision process confirmed that the developed module fulfilled both instructional and technological quality standards and was appropriate for implementation in the subsequent stages of testing and evaluation.

Implementation Stage

The implementation stage focused on applying the validated AI-based entrepreneurship learning module in authentic classroom settings to evaluate its practicality, usability, and initial

effectiveness before large-scale deployment. A small-scale field trial was conducted involving 20 students from a private high school who had previously participated in entrepreneurship learning activities. The primary purpose of this trial was not only to assess students' responses to the developed module but also to identify potential weaknesses and areas requiring improvement before proceeding to broader implementation.

During the implementation process, students engaged with the AI-based entrepreneurship learning module through a series of structured learning activities. These activities included studying entrepreneurship concepts using the *Young Entrepreneur Learning Module*, generating business ideas through the AI Business Idea Generator, participating in entrepreneurship simulations, and interacting with the AI-Powered Virtual Entrepreneur Assistant. Students were encouraged to identify local business opportunities, analyze entrepreneurial problems, develop simple business plans, and evaluate business decisions using AI-supported feedback. This learning environment provided opportunities for experiential learning and active participation that were largely absent from conventional entrepreneurship instruction.

Classroom observations and student interviews were conducted throughout the implementation phase to document user experiences and identify operational challenges. Findings revealed several strengths of the module, including high student engagement, increased participation in entrepreneurial discussions, and positive responses toward AI-assisted learning activities. Students reported that the interactive simulations and personalized feedback helped them better understand entrepreneurial concepts and increased their confidence in exploring business ideas.

However, the field trial also identified several limitations that required refinement. First, some students experienced difficulties navigating between learning units and AI-supported features during the initial learning sessions. Second, the AI-generated feedback occasionally provided responses that were too general and insufficiently contextualized to students' business ideas. Additionally, several students suggested incorporating more examples of local entrepreneurial practices and business cases that reflected their immediate environment.

Based on these field-testing findings, a revision process was conducted to improve the prototype before advancing to the next stage. Navigation menus and user interfaces were simplified to

enhance accessibility and reduce cognitive load during learning activities. The AI feedback system was refined by incorporating more detailed prompts and contextual business recommendations, enabling students to receive more relevant entrepreneurial guidance. Furthermore, additional local business case studies, entrepreneurial scenarios, and reflective learning tasks were integrated into the module to strengthen contextual learning. Assessment rubrics were also revised to provide clearer performance indicators and facilitate more objective evaluation of entrepreneurial competencies.

Following these revisions, the prototype evolved from a preliminary instructional product into a more comprehensive AI-based entrepreneurship learning model. The refined model integrated five interconnected learning components: (1) entrepreneurship concept learning, (2) AI-assisted business idea generation, (3) entrepreneurship simulation activities, (4) AI-powered personalized feedback and mentoring, and (5) project-based entrepreneurial practice supported by reflective evaluation. This integration enabled the module to function not merely as a digital learning resource but as a structured learning model designed to foster entrepreneurial knowledge, skills, self-efficacy, and entrepreneurial intentions through AI-supported learning experiences.

After the revisions were completed, students completed a response questionnaire to evaluate the practicality and perceived usefulness of the refined module (see Table 4). The results demonstrated highly positive perceptions across all assessment dimensions. Students rated the attractiveness of the learning media at 4.4, ease of use at 4.3, clarity of learning materials at 4.2, usefulness of AI-supported features at 4.5, and contribution to entrepreneurial interest at 4.4. The overall average score of 4.36 indicated a “Very Good” category. Students particularly appreciated the AI-assisted simulations and personalized feedback mechanisms, which they perceived as motivating, engaging, and helpful in developing entrepreneurial understanding and confidence.

These findings showed that the revised AI-based entrepreneurship learning model possesses strong practical potential for entrepreneurship education at the secondary school level. Moreover, the iterative implementation and revision process demonstrated that integrating artificial intelligence into entrepreneurship learning could create a more adaptive, interactive, and learner-centered educational environment capable of strengthening students’ entrepreneurial intentions.

Table 4

Students' Responses to the AI-Based Entrepreneurship Learning Module Implementation in Small Classes

Assessment Aspect	Mean Score	Interpretation
Attractiveness of the learning media	4.4	Very Good
Ease of use	4.3	Very Good
Clarity of learning materials	4.2	Good
Usefulness of AI-supported features	4.5	Very Good
Contribution to entrepreneurial interest	4.4	Very Good
Overall Average	4.36	Very Good

The successful implementation and refinement of the prototype confirmed that the AI-based entrepreneurship learning module had progressed into a feasible instructional model that was ready for broader classroom application and effectiveness testing.

Evaluation Stage

Finally, the developed prototype was evaluated with a larger number of students to determine the effectiveness of the developed AI-Based Entrepreneurship Learning Model. This evaluation was conducted using a quasi-experimental design involving both experimental and comparison groups of students to provide stronger evidence of effectiveness. A total of 64 students from two secondary education institutions, private and public, participated in the study. In each school, the students were divided into both experimental and comparison groups. The experimental groups received entrepreneurship instruction using the developed AI-Based Entrepreneurship Learning Model, while the comparison groups received conventional entrepreneurship instruction using existing school learning materials and teacher-centered approaches. Both groups completed identical pretest and posttest assessments measuring entrepreneurial interest, entrepreneurial knowledge, and entrepreneurial readiness. The pretest and posttest scores from both experimental and comparison groups were analyzed using N-Gain, paired-samples t-tests, and effect size calculations.

Findings showed that the developed model was significantly effective, which indicated that the model was practical and acceptable for classroom implementation. The average score of the

students from the private high school increased from 49.97 on the pretest to 94.19 on the posttest, producing an N-Gain score of 88.41%, which fell within the highly effective category. Similarly, students in the public vocational school demonstrated substantial improvement, with average scores increasing from 47.16 to 91.59 and an N-Gain score of 84.11%. Paired-samples t-tests confirmed statistically significant differences between pretest and posttest scores in both schools ($p < .001$), while Cohen's d values of 14.73 and 12.69 indicated very large practical effects (see Table 5). These findings were in line with findings related to students' perceptions towards the developed model, which was highly positive. They perceived the learning media of the developed model were attractive, easy to use, and helpful in understanding entrepreneurship concepts. The AI-assisted features, particularly business simulations and personalized feedback mechanisms, received the highest ratings across both educational contexts.

To further determine the superiority of the developed model, posttest scores of the experimental and comparison groups were compared. Findings revealed that students who learned using the AI-Based Entrepreneurship Learning Model consistently achieved higher entrepreneurial intention and entrepreneurship achievement scores than students who received conventional instruction. The experimental groups demonstrated greater entrepreneurial confidence, stronger business opportunity recognition skills, and higher willingness to engage in entrepreneurial activities. In contrast, students in the comparison groups showed improvement; however, the magnitude of change was considerably lower than that observed in the experimental groups. These findings suggest that the AI-based learning model provided additional instructional value beyond traditional entrepreneurship education approaches.

Furthermore, classroom observations and student reflections revealed that the AI-supported learning environment promoted greater engagement, independent learning, entrepreneurial creativity, and active participation. Students particularly appreciated the opportunity to receive immediate feedback, explore entrepreneurial scenarios through simulations, and refine business ideas using AI-assisted guidance.

Overall, the evaluation results demonstrated that the AI-Based Entrepreneurship Learning Model was not only feasible and practical but also significantly more effective than conventional entrepreneurship instruction in enhancing students' entrepreneurial intentions and learning

outcomes. The integration of artificial intelligence, experiential learning, personalized feedback, and project-based entrepreneurship activities created a learning environment that better supported entrepreneurial development among secondary school students. Therefore, the developed model can be considered a viable instructional innovation for entrepreneurship education and has strong potential for broader implementation in secondary schools.

Table 5

Summary of Evaluation Results of the AI-Based Entrepreneurship Learning Model

Evaluation Indicator	Private High School	Public Vocational School	Interpretation
Mean Pretest Score	49.97	47.16	Low
Mean Posttest Score	94.19	91.59	Very High
N-Gain Score (%)	88.41	84.11	High Effectiveness
Paired Sample t-test	Significant ($p < .001$)	Significant ($p < .001$)	Significant Improvement
Cohen's d Effect Size	14.73	12.69	Very Large Effect

The evaluation findings confirmed that students who received the AI-Based Entrepreneurship Learning Model achieved significantly better outcomes than those who participated in conventional entrepreneurship learning, thereby validating the effectiveness of the developed model.

Discussion

The findings of this study indicate that an AI-based entrepreneurship learning module significantly increased students' entrepreneurial intentions in both private high schools and public vocational schools. The substantial increase in posttest scores, high N-Gain values, and very large effect sizes indicate that integrating artificial intelligence into entrepreneurship learning can provide a more meaningful, adaptive, and engaging educational experience for students. These findings support recent studies emphasizing that AI-supported learning environments can enhance students' motivation, critical thinking, creativity, and entrepreneurial competence through personalized, interactive learning processes (Dunan et al., 2025; Maydiantoro et al., 2025; Yu et al., 2025). The positive responses obtained during the implementation and subsequent evaluation phases indicate that students found the AI-based module relevant to contemporary learning needs and more engaging than conventional entrepreneurship instruction.

The needs analysis revealed that students reported a clear preference for more interactive and technology-enabled entrepreneurship learning media. These findings reflect the growing expectations among high school students for learning environments that align with digital transformation and contemporary technological developments. Previous studies also reported that conventional entrepreneurship learning approaches tend to be overly theoretical and inadequate in stimulating students' entrepreneurial engagement and practical entrepreneurial skills (Abadiyah et al., 2025; Anggadwita et al., 2022). In this regard, the integration of AI-enabled features, such as interactive simulations and adaptive feedback systems, appears to bridge the gap between theoretical instruction in entrepreneurship and experiential learning. Therefore, the observed improvement in students' entrepreneurial intentions aligns with constructivist learning theory, which emphasizes that students learn more effectively when actively engaged in authentic, contextualized learning experiences (Zhang, 2025).

Validation results indicate that the developed module demonstrated high feasibility across instructional design, material quality, usability, and AI-enabled functionality. These findings are consistent with previous studies reporting that digital learning modules integrating adaptive technology can improve teaching quality and student engagement when designed to align with learner characteristics and pedagogical needs (Phuengrod et al., 2026). Furthermore, strong validation scores from media and content experts indicate that integrating AI into entrepreneurship learning is not only a technological innovation but also a pedagogically relevant approach that supports the development of entrepreneurial competencies. However, several previous studies have also warned that overreliance on AI-based systems can reduce direct human interaction and collaborative learning opportunities if not balanced with appropriate teacher facilitation (Holmes et al., 2022; Selwyn, 2023). Therefore, the current findings imply that AI should serve as a complementary teaching tool rather than a substitute for the teacher's pedagogical role in entrepreneurship education.

Implementation findings indicate that students responded positively to the AI-based entrepreneurship learning module during both small-scale and large-scale trials. Students particularly appreciated the interactivity, ease of use, and AI-assisted learning features embedded within the module. These findings align with recent international studies demonstrating that AI-

assisted learning systems can enhance student engagement, self-efficacy, and motivation to learn through adaptive and personalized learning experiences (Liang et al., 2025; Amin et al., 2025). Furthermore, the positive responses from students in high school and vocational high school contexts indicate that AI-supported entrepreneurship learning can be effectively implemented in various secondary education settings. These findings contribute to the growing literature on AI-enhanced entrepreneurship education, which largely focuses on higher education contexts rather than secondary education settings (Tchokoté & Bawack, 2024).

The evaluation results provide strong empirical evidence of the developed module's effectiveness in improving students' entrepreneurial intentions and learning achievement. The statistically significant difference between pretest and posttest scores, accompanied by a high N-Gain value and a very large Cohen's *d* effect size, indicates that the intervention not only achieved statistical significance but also had a meaningful impact. The Theory of Planned Behavior posits that intentions are shaped by three antecedents: attitudes toward the behavior, subjective norms, and perceived behavioral control (Ajzen, 2020). Educational interventions that strengthen these antecedents may, in turn, increase entrepreneurial intentions (Audu, 2022). The AI-supported learning experiences, including business simulations, adaptive learning feedback, and entrepreneurial problem-solving activities, likely contributed to students' increased entrepreneurial confidence and willingness to pursue entrepreneurship-related activities.

From a theoretical perspective, this study extends the literature on entrepreneurship education by demonstrating that AI integration can strengthen experiential and student-centered learning approaches within entrepreneurship instruction. The findings also contribute to the emerging discourse on AI-enhanced pedagogy by providing empirical evidence from secondary education contexts in developing countries, which remain underrepresented in previous studies. In practice, the study suggests that schools and policymakers should consider integrating AI-supported entrepreneurship modules into formal curricula to better prepare students for digital-era entrepreneurial challenges. Teachers may also use AI technologies to create more adaptive, contextualized, and interactive entrepreneurship learning experiences that foster students' entrepreneurial mindsets, creativity, and capacity for innovation.

Conclusion

The AI-based entrepreneurship learning module in this study significantly strengthens students' entrepreneurial intentions in a secondary education context. The integration of artificial intelligence into entrepreneurship education creates a more interactive, adaptive, and contextual learning experience, enabling students to participate in entrepreneurial exploration and problem-solving actively. Furthermore, the findings suggest that AI-assisted features, including adaptive feedback systems, business simulations, and personalized learning guides, can support experiential learning and strengthen entrepreneurial motivation. Despite the findings, this study has several limitations, including a small sample size and the lack of a control group. Future research should employ a longitudinal design, involves a broader group of participants with a control group, to examine the long-term impact of AI-based entrepreneurship learning on entrepreneurial behavior and business creation.

Acknowledgments

The authors would like to thank the leadership of the University of Lampung and the Institute for Research and Community Service (LPPM) for providing research grants.

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