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EconoVerse: Development and Evaluation of a Seamless Mobile Learning Application to Enhance Transformative Financial Literacy and Entrepreneurial Readiness

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Abstract. With the rapid development of the digital economy, undergraduate students require not only financial knowledge but also opportunities to apply this knowledge in realistic contexts and develop entrepreneurial readiness. However, conventional learning approaches often emphasize knowledge acquisition without sufficiently fostering behavioral change or preparing students to apply their knowledge in practice. To address this gap, this study developed and evaluated EconoVerse, an Android-based seamless mobile learning instructional medium developed to support transformative financial literacy and entrepreneurial readiness among undergraduate students. A quasi-experimental one-group pretest-posttest design was employed with 60 undergraduate Management and Marketing students. The instructional medium was developed using a research and development (R&D) approach based on the 4D model (define, design, develop, and disseminate). Data were collected through expert validation, black-box testing, practicality questionnaires, and pretest-posttest instruments. The construct validity, internal consistency, and interwaser reliability of

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the measurement instruments were evaluated using confirmatory exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and Cronbach's alpha, respectively. Effectiveness was assessed using paired-sample *t*-tests. Expert validation indicated that the content, media, and instructional design of EconoVerse were acceptable, with average scores exceeding 90%. Black-box testing confirmed that all system features functioned as intended across all test scenarios. The practicality assessment yielded a usability score of 91.86%, indicating that the system was easy to learn and applicable to students' learning needs. The effectiveness analysis demonstrated significant improvements in both transformative financial literacy ($t = 11.26, p < 0.001$) and entrepreneurial readiness ($t = 11.25, p < 0.001$). These findings indicate that EconoVerse is a valid, feasible, and efficient instructional tool for enhancing transformative financial literacy and entrepreneurial readiness among undergraduate students in the digital age.

Keywords: seamless mobile learning; transformative financial literacy; entrepreneurial readiness; Indonesia higher education; 4D model

1. Introduction

The rapid transformation of the digital economy has intensified financial insecurity, particularly among younger generations who must adapt to flexible income patterns within an expanding gig economy, the widespread use of digital payments, and rapidly changing market behaviors. In Indonesia, this challenge is reflected in the relatively low level of financial literacy. According to an annual financial report, Indonesia's national financial literacy index was 49.68% in 2022 (Otoritas Jasa Keuangan, 2023). Many students in higher education also have difficulty translating theoretical knowledge into practical applications and adaptive behaviors. Traditional pedagogical practices in universities may contribute to this problem because they often focus on passive, classroom-based learning, which does little to promote behavioral change or the preparedness needed for entrepreneurial practice.

Hasan et al. (2024) provided an overview of the socio-psychological and cognitive determinants of Generation Z's entrepreneurial readiness, demonstrating the potential of technology-based learning and digital creativity to enhance students' preparedness to engage in entrepreneurial activities. This is further supported by evidence that, in the context of Industry 4.0, digital literacy is closely related to work readiness (Rahmat et al., 2024), while financial literacy, digital marketing skills, and network connections influence entrepreneurial readiness among young learners (Kamila & Fahlia, 2025). Entrepreneurship education that incorporates digital financial literacy may also strengthen students' risk-taking capacity and entrepreneurial intention, which are necessary for sustainable venture development (Pandey & Chadha, 2026). These problems highlight the urgency of developing innovative learning approaches that can help students in Indonesia not only improve their financial literacy but also develop an interest in entrepreneurship.

Most learning in higher education is still theoretical and traditional, which particularly limits practice-based learning from becoming an integral part of the learning process. This creates a gap between understanding concepts and grounding them in real-world experiences, thereby limiting the development of practical skills. Learning environments are often passive, resulting in low student interest and insufficient interactivity, as well as failure to stimulate the engagement that drives learning. Studies show that traditional teaching approaches are not conducive to meeting the requirements of the Fourth Industrial Revolution, which requires adaptive and technology-supported learning (Sudarmansyah et al., 2019).

This is compounded by the fact that mobile learning has not yet been fully utilized in instructional practices, and the integration of digital technology remains limited. Although Android-based learning applications can strongly support hands-on and experiential learning, they have not been consistently implemented in practice-based learning contexts (Rohimah & Supriyadi, 2025; Trabelsi, 2020). Consequently, students face challenges related to higher-order thinking skills, engagement, and real-life problem-solving abilities (Khotima & Pratama, 2022).

The need for mobile learning as a new method to overcome these limitations is supported by the rapid digital transformation of education, particularly the development of Android-based mobile learning. Mobile learning offers high accessibility and flexibility, allowing students to learn anywhere and anytime while supporting self-directed and continuous learning (Hanafi & Samsudin, 2012; Novaliendry et al., 2020). The incorporation of interactive technologies, such as augmented reality and simulation-based learning, allows for immersive and engaging learning experiences that bring theoretical principles into practice (Alamsyah et al., 2023; Eliza et al., 2023). Various empirical studies have shown that Android-based learning applications, such as MoLearn, can enhance the effectiveness of the learning process while improving engagement and skills across different educational settings (Sunarto et al., 2020). I

n addition, trends in teaching and learning emphasize the increasing application of Android applications in education as a positive development, with innovative, technology-based approaches needed to support more adaptive and student-centered learning (Rohimah & Supriyadi, 2025). In this regard, seamless learning has emerged as a significant paradigm that integrates formal and informal learning contexts, enabling learners to transition between contexts while interacting with the digital learning ecosystem and engaging in continuous lifelong learning beyond the traditional classroom context. However, mobile learning presents considerable challenges that cannot be overlooked. Scholars have identified various obstacles, including the digital divide, inadequate network availability in rural areas, and potential distractions caused by technology that can affect students' attention. Another pedagogical challenge is that poorly structured or unclear learning tasks may prevent students from effectively self-regulating their learning, potentially resulting in cognitive overload or a lack of focus.

Transformative financial literacy has evolved in response to the shortcomings of traditional financial education, which tends to focus more on information acquisition than behavioral change. Contemporary perspectives indicate that financial literacy transcends the passive comprehension of economic concepts. Financial literacy is now understood as a transformative process that develops individuals' mindsets and approaches and enables them to make responsible and sustainable financial choices (Tavares & Almeida, 2025). This approach highlights cognition, emotion, and behavior, recognizing that financial knowledge alone is insufficient and that individuals also need to develop a critical awareness of the values underlying the management of financial resources (Brunstein et al., 2020). In simple terms, the adequacy of financial well-being depends on the extent to which individuals can translate financial knowledge into proactive and contextually relevant actions (Ianole-Calin et al., 2021).

In the context of sustainable development, transformative financial literacy also empowers individuals and communities to mobilize resources for informed economic decision-making, which is critical for productive investment (Kyeyune & Ntayi, 2025). Furthermore, as digital technology continues to develop, financial literacy needs to adapt to these changes and adopt a broader and future-oriented perspective (Johari, 2025), with greater attention to instructional approaches that focus on digital financial literacy concepts. Therefore, transformative financial literacy is not merely one component of entrepreneurial preparation but rather a foundational requirement for entrepreneurship, as critical, reflective, and agile financial management is essential in launching and maintaining any business endeavor.

Although research on financial literacy is developing rapidly, major gaps remain in how it can be integrated into education systems. Many financial literacy studies still tend to separate knowledge from its application (Ianole-Calin et al., 2021; Tavares & Almeida, 2025), with financial literacy viewed primarily as a cognitive construct. The outcome is a fragmented perspective in which education, implementation, and activity are perceived as distinct avenues, ultimately undermining the financial well-being model and limiting the potential effects of financial education on behavior.

At the same time, research on digital financial literacy has focused on integrating digital financial literacy with students' entrepreneurial potential as a means of enhancing economic participation and venture creation (Hasan et al., 2024; Pandey & Chadha, 2026). To date, most existing studies on financial literacy, digital literacy, and entrepreneurial readiness have not considered these three constructs in tandem or as part of a broader framework that connects them within a learning model (Kamila & Fahlia, 2025; Wahhab et al., 2025). This translates to the need for a comprehensive and paradigm-shifting approach to support the transition from financial education driven primarily by knowledge acquisition to behavior-driven financial learning.

At the same time, mobile learning technologies provide a new opportunity to improve the accessibility and efficiency of education systems in different countries. Android-based learning platforms are reported to offer flexible, interactive, and student-centered learning environments that can support continuous and self-directed learning (Hanafi & Samsudin, 2012; Novaliendry et al., 2020). Empirical findings indicate that mobile learning applications have the potential to enhance learning, engagement, and hands-on skills through interactive and technology-mediated learning opportunities (Eliza et al., 2023; Sunarto et al., 2020).

However, many studies on mobile learning still focus on technical aspects, such as system development, usability, and media effectiveness, without incorporating domain-specific competencies (Balanskat & Engelhardt, 2015; Wang & Lin, 2021), while other studies focus solely on financial literacy learning in general (Rohimah & Supriyadi, 2025; Trabelsi, 2020). Additionally, although interactive technologies such as augmented reality and simulation systems have been studied, their use to promote financial decision-making and entrepreneurship readiness remains limited (Alamsyah et al., 2023; Khotima & Pratama, 2022). These limitations demonstrate the absence of a structured instructional model that integrates mobile learning with transformational financial and entrepreneurial competencies.

This study addresses these empirical and theoretical gaps directly by developing EconoVerse, a seamless Android-based mobile learning platform for transformative financial literacy and entrepreneurial readiness. EconoVerse follows an R&D 4D model that develops, implements, and evaluates the platform from technical, pragmatic, and instructional perspectives. The study provides a multidimensional theoretical framework describing how mobile learning environments can help translate theory into reflective and sustainable entrepreneurship among undergraduate students.

Guided by an instructional design model that bridges theory and practice (Brunstein et al., 2020; Kyeyune & Ntayi, 2025), this study presents an innovative approach to mobile financial literacy interventions by integrating cognitive, affective, and behavioral affordances within an immersive mobile learning environment. A unique feature of this study is the integration of mobile learning, transformative financial literacy, and entrepreneurial readiness through a single application that can facilitate embedded learning. This evidence-based framework can guide the development of educational technology and improve the financial habits, attitudes, and behaviors of students preparing to thrive in a rapidly changing digital economy.

The purpose of this study was to develop EconoVerse, an Android-based instructional medium for transformative financial literacy and entrepreneurial readiness, and to determine its effectiveness. Specifically, the study aimed to:

1. Determine the content, instructional design, and technical validation results of the developed medium.
2. Assess system usability through black-box testing.

3. Assess the practicality of the learning medium.
4. Determine its effectiveness in improving students' financial decision-making skills and preparedness for entrepreneurship.

2. Literature Review

2.1 Theoretical Framework: Integrating Transformative Learning Theory and Seamless Mobile Learning

Transformative learning theory (TLT) provides a well-developed conceptual foundation for understanding how learning can change the way learners view situations through changes in perspective, attitude, or behavior. It focuses on critical reflection, experiential learning, and the transformation of previously held knowledge into new and more adaptive ways of thinking and acting (Lange, 2019; Stansberry, 2023). The literature indicates that transformative learning is often linked to the integration of theory and practice in educational technology contexts (Priya et al., 2024), where learners engage with authentic tasks and real-world problem-solving.

Studies show that digital learning environments, including virtual and mobile platforms, can facilitate transformative learning experiences through interaction, reflection, and adaptive feedback (Rajagopal & Mateusen, 2021). Transformative learning is also associated with and integrated into broader constructs such as transformative financial literacy and entrepreneurial readiness, as both require cognitive understanding accompanied by behavioral change in decision-making. The link between TLT and the ability to critically evaluate financial situations, consider economic choices, and apply knowledge in an entrepreneurial context provides a strong theoretical lens for understanding how instructional media such as EconoVerse can influence students' financial behavior and preparedness for venture creation.

Nevertheless, seamless mobile learning can augment transformative learning by creating a continuous and context-integrated environment that connects formal (face-to-face), informal (collaborative), and digital (virtual-simulated) learning spaces. Seamless learning (Noguera et al., 2026; Wong et al., 2021) emphasizes student engagement across time, place, and context through mobile technologies that enable students to participate continuously in ongoing learning experiences. The development of m-learning in higher education has shown its potential to increase access, flexibility, and learner engagement through personalized and interactive learning environments (Naveed et al., 2023; Okai-Ugbaje et al., 2022).

Studies have also shown that seamless mobile learning environments can foster concept mastery, collaborative learning, and the contextual application of knowledge (Chung et al., 2019; Hamid et al., 2019). In addition, the application of learning analytics in seamless learning environments can support an adaptive learning process that responds to learners' needs and performance (Moon et al., 2024). In this study, seamless mobile learning provides the theoretical and pedagogical foundation for the independent variable, namely the EconoVerse Android-based instructional medium. The EconoVerse platform is designed to support continuous, experiential, and behavior-based learning by combining

seamless learning principles with transformative learning processes to enhance students' transformative financial literacy and entrepreneurial readiness (Samuel, 2023) (see Figure 1).

The body of literature supporting the relevance of educational technology and the benefits of its integration into contemporary pedagogy is growing. However, most prior work on mobile-based financial education lacks theoretical grounding and critical analyses of opposing empirical findings. Although many researchers highlight the benefits of various technological solutions, a counter-narrative exists, including examples in which mobile interventions had little or no effect because users resisted the software features, fatigue occurred on the platform side, or technological limitations were present. Moreover, prior studies often regard mobile learning as a means of accelerating performance and fail to identify the specific mechanisms through which m-learning environments can lead to behavioral change rather than simply increased knowledge.

Most current implementation and assessment frameworks oversimplify this phenomenon by assuming a direct linear relationship without considering potential mediators, such as learning participation, perceptions of learning, and ownership, alongside important moderators, such as baseline digital competence and socio-economic differences. As a result, existing models do not adequately explain when and how seamless mobile learning successfully translates theoretical economic concepts into sustained entrepreneurial action in different contexts. This study addresses these theoretical gaps through the development of EconoVerse, a multidimensional framework that explicitly describes a pathway from digital learning to behavioral change.

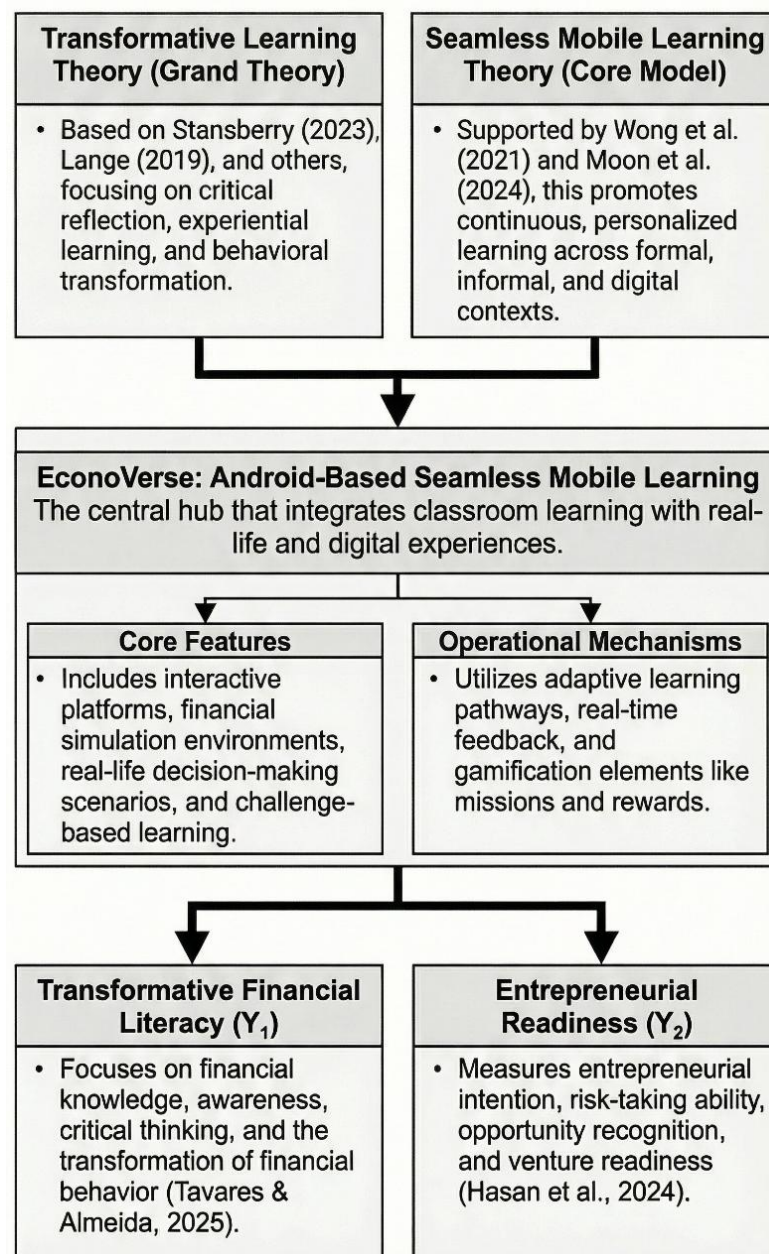


Figure 1: Theoretical framework

2.2 Conceptual Framework and Variables

To examine how Android-based instructional media (i.e., EconoVerse) can enhance students' transformative financial literacy and entrepreneurial readiness, the conceptual framework of this research combines TLT with seamless mobile learning theory. The main difference between TLT and other models lies in its emphasis on critical reflection, experiential learning, and a change in behavior, moving learners beyond simply consuming knowledge towards transforming decisions and applying knowledge directly (Lange, 2019; Priya et al., 2024; Stansberry, 2023). This approach aims to develop not only an understanding of financial principles but also the ability to deal with increasingly complex and changing economic environments in financial education. Hence, transformative financial literacy is framed as a desired target state that represents the integration

of cognitive, affective, and behavioral dimensions of financial capability. The conceptual framework is summarized in Table 1.

Table 1: Conceptual framework and variables

Variable	Dimension	Indicator	References
EconoVerse (X)	Interactive learning system	Interactive mobile interface	Samuel (2023); Noguera et al. (2026)
		Financial simulation features	
		Decision-making scenarios	
	Adaptive learning mechanism	Adaptive learning pathways	Naveed et al. (2023); Moon et al. (2024)
		Real-time feedback system	
		Personalized learning experience	
	Seamless learning integration	Learning across contexts	Wong et al. (2021); Okai-Ugbaje et al. (2022)
		Continuous learning experience	
		Integration of classroom and real-life learning	
Transformative financial literacy (Y₁)	Financial knowledge	Understanding basic financial concepts	Tavares and Almeida (2025)
		Understanding financial risks and returns	
		Understanding digital financial services	
	Financial awareness	Awareness of personal financial condition	Brunstein et al. (2020)
		Awareness of financial planning importance	
		Awareness of responsible financial behavior	
	Financial behavior	Ability to manage personal finances	Ianole-Calin et al. (2021); Johari (2025)
		Ability to make rational financial decisions	
		Consistent financial practices	
Entrepreneurial readiness (Y₂)	Entrepreneurial intention	Interest in starting a business	Hasan et al. (2024)
		Motivation to become an entrepreneur	
		Willingness to pursue opportunities	
	Decision-making ability	Ability to analyze business opportunities	Wahhab et al. (2025)
		Ability to make strategic decisions	
		Ability to evaluate risks	
	Business readiness	Readiness to plan a business	Kamila and Fahlia (2025); Pandey and Chadha (2026)
		Readiness to manage resources	
		Readiness to implement business	

Instead, seamless mobile learning underpins the technology and pedagogy for lifelong learning, in which formal, informal, and digital spaces are connected. This approach encourages a more adaptable environment, in which learners can access resources independently across different times and locations while participating in interactive and adaptive learning activities (Naveed et al., 2023; Noguera et al., 2026; Wong et al., 2021). EconoVerse is an Android-based instructional medium that utilizes financial simulations, scenario-based decision-making training, and entrepreneurship simulations, augmented with adaptive learning mechanisms for feedback to enhance effectiveness. These features create an experience-based learning environment for developing financial decision-making skills and entrepreneurial competencies. The integration of seamless learning with mobile technologies has been shown to support engagement, personalization, and contextual learning, which are important for developing higher-order thinking and practical skills (Chung et al., 2019; Moon et al., 2024; Okai-Ugbaje et al., 2022).

According to this theoretical construct, EconoVerse, as an Android-based mobile learning instructional medium, represents the independent variable, while transformative financial literacy and entrepreneurial readiness represent the dependent variables. Transformative financial literacy embodies the students' capacity to process, analyze, and apply financial knowledge in real-life situations, while entrepreneurial readiness represents the extent to which students are prepared to start and operate a business. Previous studies have extensively examined the importance of financial literacy in decision-making related to entrepreneurial activities (Hasan et al., 2024; Kamila & Fahlia, 2025; Pandey & Chadha, 2026). The present study, therefore, proposes that EconoVerse not only has a direct effect on transformative financial literacy but also has direct and indirect effects on entrepreneurial readiness.

2.3 Hypotheses Framework

The hypotheses of this study were developed by integrating transformative learning principles and foundations of a seamless mobile learning environment implemented through the EconoVerse platform and guided by action-oriented testing. Mobile learning, for instance, has emerged as an effective educational technology with the potential to improve accessibility, engagement, and flexibility in learning processes (Hossain et al., 2021; Pratiwi et al., 2025), including entrepreneurship education.

Digital and mobile-based learning environments enable learners to participate in interactive content, simulations, and real-life scenarios, thus allowing them to engage in experiential and reflective learning processes. Digital learning environments in entrepreneurship contexts have also helped bridge the gap between knowledge and practice and facilitated the development of innovation competencies, collaboration competencies, and financial decision-making capabilities (Chen et al., 2021; Prokopenko et al., 2024). In addition, various studies have shown that mobile learning platforms encourage collaborative learning opportunities while also developing critical thinking and problem-solving abilities, which are key areas of financial literacy and entrepreneurial competence

(Lee et al., 2016; Wu et al., 2019). The hypotheses framework is presented in Table 2.

Table 2: Hypotheses framework

Code	Hypothesis statement
H ¹	EconoVerse-based seamless mobile learning has a significant positive effect on students' transformative financial literacy.
H ²	EconoVerse-based seamless mobile learning has a significant positive effect on students' entrepreneurial readiness.

The convergence of mobile technology and entrepreneurship education also supports learners' entrepreneurial readiness by developing their ability to identify opportunities, manage resources, and make strategic decisions in ever-changing environments (Zahra & Mudambi, 2025). Research has shown that mobile-based applications and digital devices can help students understand business processes, including financial management and regulatory issues, thereby increasing their readiness for business engagement (Umami et al., 2023). Moreover, mobile learning environments enable adaptive and personalized learning experiences that can help develop entrepreneurial skills and financial behaviors through continuous interaction and contextual learning (Med & Lukyamuzi, 2019; Moein et al., 2015). EconoVerse is proposed as a seamless mobile learning-based Android instructional medium that is expected to improve students' transformative financial literacy and entrepreneurial readiness through interactive, experiential, and adaptive learning processes, based on theoretical and empirical foundations.

3. Methodology

3.1 Research Design

This study employed an R&D method using the 4D model (define, design, develop, and disseminate) to develop an Android-based seamless mobile learning instructional medium called EconoVerse as an innovation in digital learning tools for increasing students' transformative financial literacy and entrepreneurial readiness. The research design combined the product development process with a quasi-experimental one-group pretest-posttest design to assess the effectiveness of the developed medium in relation to two dependent variables: transformative financial literacy (Y_1) and entrepreneurial readiness (Y_2). A one-group design was used because of practical limitations, including the need to provide equal access to the developed learning innovation and the lack of appropriate and available comparable control groups within the specific academic program. This approach is suitable for the initial evaluation of educational technology products, with an emphasis on developing, validating, and testing their initial effectiveness.

The 4D development model provides a structured approach consisting of the following four stages (see Figure 2):

1. **Define:** This stage involved a needs analysis relating to financial literacy and entrepreneurial readiness, a review of entrepreneurship education practices, and an assessment of learners' requirements in the context of digital and mobile learning environments.

2. **Design:** This stage covered the design of the EconoVerse mobile learning system, including its financial simulation features, decision-making scenarios, and entrepreneurial challenge-based learning activities aligned with seamless learning principles.
3. **Develop:** This stage involved creating the prototype; conducting expert validation of the content, media, and instructional design; testing system functionality; assessing practicality; and iteratively refining the product.
4. **Disseminate:** This stage involved preparing the instructional medium for implementation and reporting the results to support broader implementation and publication.

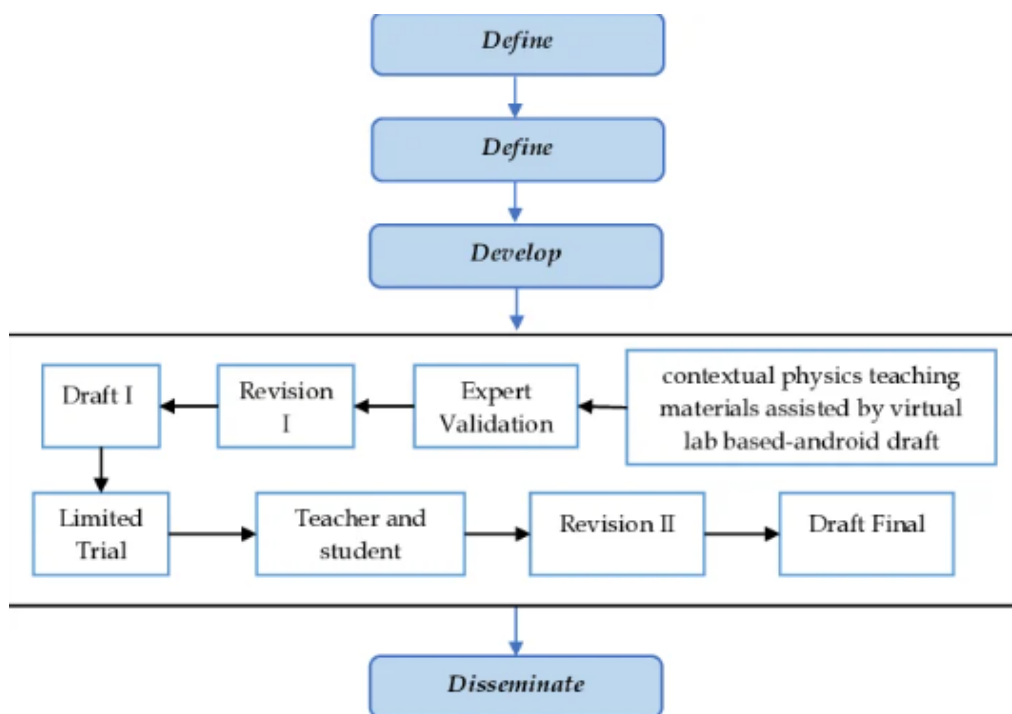


Figure 2: 4D Model

3.2 Research Setting and Participants

The research was carried out at the Faculty of Economics and Business, PGRI Jombang University, which has supporting digital infrastructure for technology-enhanced learning. The research sample consisted of 60 undergraduate Management and Marketing students (Academic Year 2024/2025), selected through purposive sampling based on course relevance, digital readiness, and voluntary consent to participate in the study. The EconoVerse intervention was tested over a period of 6 months by applying a blended learning approach in 3 independent 90-minute sessions in 1 month (total: 12 hours). The EconoVerse intervention was implemented over a 6-month period using a blended learning approach. Participants engaged in periodic 90-minute sessions, culminating in a total of 12 instructional hours. Students engaged in asynchronous exploration, financial simulations, and entrepreneurial challenges within the application, supplemented by supervised practical online activities and classroom instruction. All ethical principles, including voluntary informed consent and confidentiality of the collected data, were strictly adhered to.

3.3 Data Collection Techniques and Instruments

In this study, data collection consisted of four stages: expert validation, system functionality testing, practicality testing, and effectiveness testing of the developed EconoVerse mobile learning system (Table 3). Expert validation ensured that the EconoVerse platform met academic and technical standards for financial literacy content, instructional design, and usability. At the same time, black-box testing ensured that each application functionality worked as intended according to the technical specifications. User experience and accessibility were assessed through student practicality questionnaires, while a pretest-posttest framework was used to assess the empirical effectiveness of the platform in improving transformative financial literacy and entrepreneurial readiness. These stages ensured that the product was valid, functional, practical, and effective as an innovative instructional medium.

Table 3: Data collection techniques and instruments

No	Data type/ purpose	Technique - instrument	Indicators	N item	Respondents
1	Expert validation - financial literacy content	Content expert questionnaire	- Alignment with financial literacy and entrepreneurship curriculum - Accuracy and relevance of financial concepts - Adequacy of financial and entrepreneurial topics - Contextual relevance to real-life financial situations - Clarity and readability of content - Appropriateness of financial case examples - Integration of digital financial literacy elements - Suitability of learning objectives and assessments	22	2 financial literacy/ entrepreneurship experts
2	Expert validation - learning medium	Media expert questionnaire	- Interface usability and navigation - Visual design consistency and accessibility - Quality of multimedia and simulation features - System performance and stability - Compatibility across devices - Interactivity and responsiveness - Data security and privacy - Technical support availability	24	2 media/IT experts

3	Expert validation – instructional design	Instructional design expert questionnaire	- Alignment between objectives, activities, and evaluation - Effectiveness of learning strategies - Implementation of seamless mobile learning - Clarity of feedback and learning progression - Authentic financial and entrepreneurial scenarios - Cognitive load management - Student engagement strategies - Feasibility in educational settings	24	2 instructional design experts
4	System functionality	Black-box testing scenarios	- User registration and login - Navigation within the application - Financial simulation features - Decision-making scenario functionality - Data processing and storage - Compatibility across devices	15	Research team
5	Practicality (usability)	Student practicality questionnaire	- Ease of use - Clarity of instructions - System performance smoothness - Efficiency of learning time - Relevance to course content - Perceived usefulness - Intention to reuse the application	14	60 students
6a	Effectiveness – transformative financial literacy	Pre-post questionnaire financial literacy scale	- Financial knowledge - Financial awareness - Financial behavior	9	60 students
6b	Effectiveness – entrepreneurial readiness	Pre-post questionnaire entrepreneurial readiness scale	- Entrepreneurial intention - Decision-making ability - Business readiness	9	60 students

3.4 Data Analysis

In this study, data were analyzed using descriptive and inferential statistics to assess the quality, practicality, and effectiveness of the Android-based seamless mobile learning system through EconoVerse (Table 4). Descriptive analysis was used to summarize expert validation, functionality, and practicality scores as percentages, with a minimum viability threshold of $\geq 70\%$. In black-box testing, system functionality was assessed based on the design specifications. The construct validity and reliability of the instrument were assessed using

exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and Cronbach's alpha. Finally, inferential analysis employed paired-samples *t*-tests to compare pretest and posttest scores and determine whether the platform significantly improved students' transformative financial literacy and entrepreneurial readiness.

Table 4: Data analysis techniques

No	Data type/ purpose	Analysis technique	Description of analysis	Decision criteria
1	Expert validation – financial literacy content	Descriptive statistics (percentage)	Convert expert evaluation scores into percentage values to determine the validity of financial literacy and entrepreneurship content.	$\geq 70\%$ = valid; $< 70\%$ = revise
2	Expert validation – learning medium	Descriptive statistics (percentage)	Analyze media expert ratings to evaluate system usability, interface design, and technical quality.	$\geq 70\%$ = valid; $< 70\%$ = revise
3	Expert validation – instructional design	Descriptive statistics (percentage)	Assess the alignment between learning objectives, activities, and evaluation in the instructional design.	$\geq 70\%$ = valid; $< 70\%$ = revise
4	System functionality (black box)	Functional suitability testing	Evaluate whether system features such as login, navigation, simulations, and data processing operate correctly.	$\geq 90\%$ success = functional
5	Practicality (usability)	Descriptive statistics (percentage)	Convert student responses into percentage scores to determine ease of use, usefulness, and user satisfaction.	$\geq 70\%$ = practical; $< 70\%$ = revise
6a	Effectiveness – transformative financial literacy	Inferential statistics (paired- samples <i>t</i> -test)	Compare pretest and posttest scores to identify significant improvements in financial knowledge, awareness, and behavior.	Sig.: $p < 0.05$ = significant improvement
6b	Effectiveness – entrepreneurial readiness	Inferential statistics (paired- samples <i>t</i> -test)	Compare pretest and posttest scores to evaluate improvements in entrepreneurial intention, decision-making ability, and business readiness.	Sig.: $p < 0.05$ = significant improvement

4. Results and Findings

4.1 Design and Development Results

4.1.1 *EconoVerse: Android-based seamless mobile learning system design*

The EconoVerse Android-based seamless mobile learning system design integrates mobile learning technology, transformative financial literacy, and entrepreneurial readiness within a single pedagogical platform. The system is designed to deliver interactive, adaptive, and experiential learning experiences,

allowing students to explore financial concepts, engage in decision-making situations, and develop entrepreneurial skills. The system connects classroom learning with real-life financial situations and the digital environment through seamless learning principles, enabling students to learn continuously across different contexts. EconoVerse allows students to learn in a more personalized manner through tools such as financial simulation games, entrepreneurship challenges, and adaptive learning pathways. The use of real-time feedback, gamification elements, and scenario-based learning enables students to engage in financial decision-making and entrepreneurial problem-solving. Implementing such a comprehensive system requires multiple core components that work together to support usability, interactivity, and transformative learning outcomes. The system design is summarized in Table 5 and presented schematically in Figure 3.

Table 5: EconoVerse mobile learning system design

No	Component	Description	Implementation in learning
1	Management and support	Administrative control for managing users, monitoring learning activities, and analyzing student progress.	Lecturers manage student accounts, track learning activities, and evaluate students' financial literacy and entrepreneurial performance through system analytics.
2	Security and privacy	Provides secure login, authentication systems, and protection of user data.	Students access the application through secure accounts, ensuring data privacy and safe storage of learning progress.
3	Assessment and feedback	Includes adaptive assessments, financial tasks, and real-time feedback mechanisms.	Students complete financial simulations and entrepreneurial tasks and receive immediate feedback on their decisions and performance.
4	Collaboration and interaction	Supports discussion, collaboration, and peer interaction in learning activities.	Students engage in group discussions, share business ideas, and collaborate in solving entrepreneurial case scenarios.
5	Personalization and accessibility	Provides adaptive learning pathways based on student progress and learning preferences.	Learning content, difficulty levels, and challenges are adjusted according to students' performance and are accessible via smartphones anytime and anywhere.
6	Content and learning interaction	Provides financial learning materials, simulations, and scenario-based activities.	Students explore budgeting simulations, investment decisions, and business planning scenarios in real-life contexts.
7	Gamification and adaptive mechanisms	Integrates rewards, levels, missions, and adaptive challenges to enhance engagement.	Students earn points, badges, and achievements when completing financial tasks and entrepreneurial challenges.
8	Infrastructure	Supported by mobile-based systems, cloud storage, and stable Internet connectivity.	The application operates efficiently on Android devices, enabling continuous learning both online and offline (limited features).

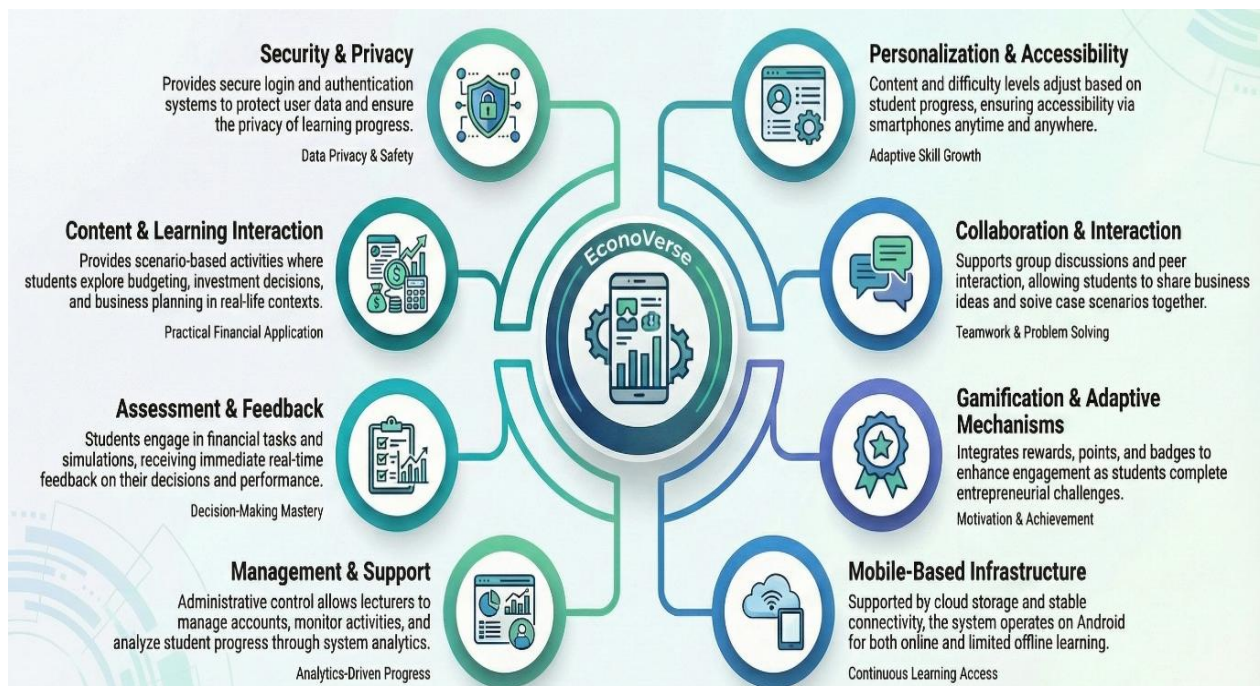


Figure 3: EconoVerse Android-based seamless mobile learning

4.1.2 System process flow

The system process flow (Figure 4) reflects a seamless mobile learning environment in which transformative learning in financial literacy and entrepreneurial readiness is operationalized through EconoVerse Android. The system integrates classroom lectures with simulated and real-life financial challenges through a digital environment, incorporating adaptive learning mechanisms, financial simulations, and entrepreneurship pedagogy through a mobile platform. Thus, the system provides a continuous, interactive, and experiential learning process that supports cognitive understanding and behavioral change in financial decision-making and entrepreneurship.

The first stage is Login and Initial Assessment, in which students log into the EconoVerse app and complete a pretest to determine their baseline financial knowledge, awareness of personal financial matters (with an emphasis on entrepreneurship), and current competency in developing and pursuing business ideas. The results are then stored in the Learning Database, which serves as the underlying database for generating personalized learning pathways. Based on the resulting learner profiles, the system implements Adaptive Recommendations, evaluating students' answers and learning profiles over time to assign appropriate financial modules, simulations, and entrepreneurial activities.

The system then proceeds to a scenario selection process, in which students experience different types of financial and entrepreneurship-based scenarios, such as budgeting decisions, investment simulations, and business plan writing. The scenarios are selected from the Financial Learning Scenario Database (FLSDB) and consist of real-world financial situations and entrepreneurship problem-solving cases. The selected scenarios are then introduced through the Mobile

Learning Interface, engaging students in simulations, decision-making, and problem-solving activities within the application.

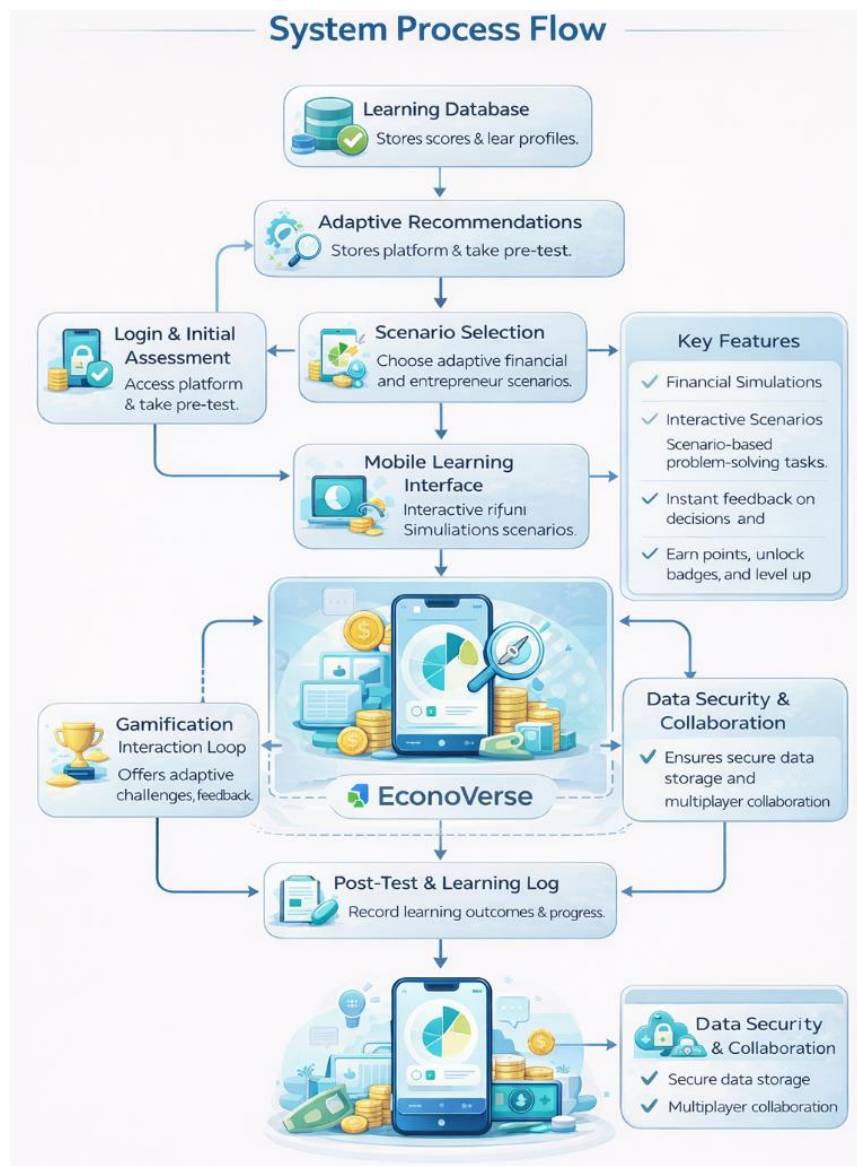


Figure 4: System process flow

The Gamification Interaction Loop is a key component for promoting engagement and learning. Students engage in adaptive challenges, in which financial missions and entrepreneurial tasks are adjusted according to their performance. Features such as points, badges, and achievement levels use gamification to encourage participation and maintain user interest. Real-Time Feedback allows students to evaluate their decisions throughout the process, enabling them to explore the consequences of their choices as they develop their financial and entrepreneurial skills.

Next is the Post-Test and Learning Log, which compiles and analyzes students' performance, progress, and attendance. The posttest measures change in transformative financial literacy and entrepreneurial readiness, while Learning Log entries document the extent of each student's involvement in the process and observed behaviors that indicate learning. This provides detailed data for tracking students over time, measuring learning outcomes, and making instructional decisions based on the data. Overall, the EconoVerse system process flow provides a flexible and structured learning system that supports ongoing learning, personalized onboarding, and lessons and practice focused on developing practical financial and entrepreneurial skills.

4.1.3 EconoVerse learning material and user interface design

EconoVerse is built using a user interface (UI) approach that serves as the main environment through which users interact with, and access knowledge related to entrepreneurship and financial literacy (Figure 6). The user interface combines intuitive navigation, visual clarity, and interactive components to support smooth mobile learning. Through this interface, students can access various financial literacy content, ranging from budgeting simulations to investment decision-making tasks to entrepreneurial planning scenarios. The design is based on user-centered principles that support accessibility and usability, combined with elements of engagement that allow students to participate in a structured yet flexible digital experience relevant to financial concepts.



Figure 5: EconoVerse user interface design visualization

The user interface design incorporates adaptive learning that delivers customized learning paths by using students' diagnostic, progress, and performance data. Interactive elements such as financial simulations, quizzes, and scenario-based activities are integrated into the platform, enabling students to learn through experience and real-time decision-making. Through calculation and feedback functions, the interface further allows learners to assess their financial decisions and refine their strategies. Visually oriented elements, such as icons, dashboards, and progress indicators, or any visuals that aid comprehension, support user cognition by presenting complex financial concepts in an easily understandable form.

Additionally, gamified and social features are integrated into the EconoVerse user interface to enhance student engagement and motivation. Within the platform, students can participate in discussion forums, post entrepreneurial ideas, and collaborate to solve simulated business problems. The interface contains visible gamification elements, such as points, badges, and levels, to indicate users' learning progress and encourage active participation. The user interface design supports continuous learning through the integration of classroom activities, mobile interaction, and real-life financial practice. Through this well-structured and interactive user interface, EconoVerse supports the development of transformative financial literacy and entrepreneurial readiness among students.

4.2 Expert Validation Results

Before the learning activities were conducted using the system, expert validation was carried out as a preliminary stage to assess the quality, validity, and feasibility of the Android-based seamless mobile learning system, EconoVerse (Table 6). The validation process involved three types of experts: financial literacy and entrepreneurship content experts, media and technology experts, and instructional design experts. The experts evaluated the system using predetermined criteria related to content accuracy, system quality, and pedagogical alignment with students' needs. The evaluation results were expressed as percentages, with a threshold of 70% indicating that the developed system was feasible to proceed to the subsequent testing phases.

Overall, the content validation for financial literacy and entrepreneurship received an average score of 90.6%, indicating that the learning materials developed were relevant, accurate, and aligned with curriculum expectations. Experts noted that the materials effectively blended authentic financial situations with basic and advanced digital financial literacy skills and entrepreneurship concepts, which could help students develop strong money-management skills. Clear explanations were further supported by relevant financial case examples, while their use in a mobile learning environment enhanced the content. According to the data, the validation of the learning media reached an average value of 93%, indicating that EconoVerse was a highly interactive and stable platform. The quality of the multimedia content, interactivity, and cross-device compatibility further demonstrated the value of the application for mobile learning across devices. The system's real-time feedback and interactive simulations also supported user engagement through experiential learning processes.

The validation of the instructional design yielded a score of 90.9%, indicating alignment among the learning objectives, activities, and assessment strategies. These components combine to provide financial and entrepreneurial contexts that support high-quality learning experiences, with the authenticity of these scenarios enhanced by adaptive learning features and feedback mechanisms. The instructional design also manages cognitive load effectively and demonstrates that the system can be applied in higher education contexts. Overall, all validation results exceeded the minimum feasibility threshold, confirming the validity of EconoVerse in terms of its media, content, and instructional design. The

development results confirm that the instructional medium is ready for practicality testing and effectiveness evaluation.

Table 6: Expert validation results

No	Type of validation	Indicators	Result (%)	Category
1	Financial literacy & entrepreneurship content expert validation	Alignment with financial literacy and entrepreneurship curriculum	91.80	Valid
		Accuracy and relevance of financial concepts	89.60	Valid
		Adequacy of financial and entrepreneurial topics	90.20	Valid
		Contextual relevance to real-life financial situations	92.10	Valid
		Clarity and readability of content	91.50	Valid
		Appropriateness of financial case examples	88.90	Valid
		Integration of digital financial literacy elements	89.80	Valid
		Suitability of learning objectives and assessments	90.70	Valid
	Total content validation		90.60	Valid
2	Learning media expert validation	Interface usability and navigation	92.40	Valid
		Visual design consistency and accessibility	93.10	Valid
		Quality of multimedia and simulation features	94.00	Valid
		System performance and stability	92.80	Valid
		Compatibility across devices	93.20	Valid
		Interactivity and responsiveness	94.10	Valid
		Data security and privacy	92.90	Valid
		Technical support availability	91.70	Valid
	Total media validation		93.00	Valid
3	Instructional design expert validation	Alignment between objectives, activities, and evaluation	91.30	Valid
		Effectiveness of learning strategies	90.10	Valid
		Implementation of seamless mobile learning	89.70	Valid
		Clarity of feedback and learning progression	91.00	Valid
		Authentic financial and entrepreneurial scenarios	92.50	Valid
		Cognitive load management	89.90	Valid
		Student engagement strategies	91.80	Valid
		Feasibility in educational settings	90.60	Valid
	Total instructional design validation		90.90	Valid

The high expert validation scores, which were generally above 90%, and the practicality score of 91.86% should be interpreted with caution, as these exceptionally high scores warrant consideration beyond a straightforward positive assessment. High and consistent scores in learning technology evaluations may indicate a ceiling effect, whereby the instruments have limited ability to detect residual weaknesses because scores are concentrated near the upper limits. Additionally, the potential for response bias, including social desirability among expert raters and participant response tendencies during survey administration, cannot be completely excluded. These potential limitations

suggest that, although EconoVerse demonstrated strong overall feasibility, the results may not fully capture specific user experience issues or practical barriers to its adoption. To address these potential limitations, supplementary research using self-reported questionnaires in combination with triangulated methods could provide a more comprehensive and nuanced evaluation of the platform. Such approaches could include qualitative focus group discussions, user experience assessments, and task-specific performance measures to provide a more substantive, evidence-based evaluation of the platform's sustainability.

4.3 Construct Validity and Reliability of Measurement Instruments

To confirm the psychometric quality of research instruments, all study variables underwent construct validity and reliability testing. Each indicator was assessed based on its standardized factor loading in the CFA of the measurement model (Table 7). Cronbach's alpha coefficients were used to assess the reliability of each construct. The analysis focused on two constructs: transformative financial literacy and entrepreneurial readiness, each comprising three dimensions and contributing to a total of six indicators.

Table 7: Results of the confirmatory factor analysis (CFA) and reliability testing

Variable	Indicators	Number of items	Standardized factor loading (λ)	Cronbach's alpha
Transformative financial literacy	Financial knowledge	3	0.65 – 0.84	0.88
	Financial awareness	3	0.67 – 0.86	
	Financial behavior	3	0.69 – 0.88	
Entrepreneurial readiness	Entrepreneurial intention	3	0.66 – 0.85	0.86
	Decision-making ability	3	0.68 – 0.87	
	Business readiness	3	0.70 – 0.89	

As stated above, the CFA results show that all indicators have standardized factor loadings greater than 0.60, providing evidence of acceptable construct validity for the respective variables. The results also indicate that the indicators adequately represent the dimensions of transformative financial literacy and entrepreneurial readiness. The high factor loadings across all dimensions further support the validity of the measurement structure and its capacity to capture the cognitive and behavioral aspects of financial and entrepreneurial competencies.

The reliability analysis also indicates good internal consistency across all constructs. Cronbach's alpha values ranged between 0.86 and 0.88, exceeding the widely accepted threshold of 0.70. This indicates that the measurement instruments can consistently measure the constructs across the items within each construct. The results therefore demonstrate adequate construct validity and internal consistency of the measurement instruments. Overall, the standardized factor loadings were within acceptable levels, while the reliability coefficients indicated good internal consistency. These findings support the statistical validity and reliability of the measurement model. Accordingly, the instruments were

considered suitable for subsequent data analyses and hypothesis testing, thereby supporting the validity and reliability of the research outcomes.

4.4 Black-Box Testing Results

This study included black-box testing to assess the functional performance of the EconoVerse online-based mobile application, which integrates mobile learning characteristics, on Android-based mobile devices before it was used in learning activities (Table 8). The testing consisted of independent validation across six primary scenarios with fifteen indicators aligned with key functional areas of the application: (1) user registration and login; (2) navigation between application features; (3) financial simulation; (4) business decision-making scenario logic; (5) data processing and storage; and (6) support for multiple devices. For each indicator, system functionality was compared with the expected behavior to determine whether all functions operated correctly, consistently, and without faults.

Table 8: Black-box testing results

Test scenario	Indicator	Expected result	Actual result	Status
User registration and login	a. Account registration	Users can create new accounts successfully	The system successfully created user accounts without errors	Pass
	b. User login authentication	Registered users can log in securely	Login authentication verified user access correctly	Pass
	c. Dashboard access	System displays main interface after login	Dashboard displayed properly after login	Pass
Navigation inside the application	a. Menu navigation	Users can navigate menus smoothly	Navigation between menus functioned properly	Pass
	b. Content access	Users can access learning modules easily	Learning content loaded correctly	Pass
Financial simulation features	a. Simulation execution	Financial simulations run properly	Simulation features operated smoothly without errors	Pass
	b. Simulation interaction	Users can interact with simulation elements	Interaction within simulations worked accurately	Pass
Decision-making scenario functionality	a. Scenario selection	Users can select financial scenarios	Scenario selection functioned properly	Pass

Test scenario	Indicator	Expected result	Actual result	Status
	b. Decision input	Users can input decisions within scenarios	Decision input was recorded correctly	Pass
	c. Feedback system	System provides real-time feedback	Feedback was delivered instantly after user actions	Pass
Data processing and storage	a. Learning progress storage	User progress is stored automatically	Learning data stored accurately in database	Pass
	b. Data retrieval	System retrieves user data correctly	Stored data displayed correctly when accessed	Pass
	c. Error handling	System handles errors appropriately	Error messages displayed clearly without a system crash	Pass
Compatibility across devices	a. Smartphone compatibility	Application runs on Android devices	Application functioned smoothly on smartphones	Pass
	b. Tablet compatibility	Application runs on tablets	System operated normally on tablets	Pass
	c. Cross-device consistency	Features are consistent across devices	No significant differences across devices	Pass

The black-box testing results showed that all six test scenarios demonstrated the functional properties initially across 15 test functions and 11 specifications. Users were able to create accounts and log in successfully, providing secure access to the system. Navigation throughout the application was smooth, allowing users to access learning materials and other features easily. The financial simulations and scenario-based activities functioned as intended, supporting interactive and experiential learning activities. Moreover, data processing and storage functioned as expected, and user progress and learning activities were appropriately tracked. The error-handling mechanism also functioned properly by providing notifications without affecting system performance. Compatibility testing verified that the application ran appropriately on devices such as Android smartphones and tablets. Overall, these results demonstrated that the system developed functioned correctly and provided a stable system for use in the learning process.

4.5 Practicality (Usability) Test Results

To assess ease of use, clarity, performance, and overall user experience, a practicality (usability) test of the EconoVerse Android-based seamless mobile learning system was conducted with students (Table 9). The test consisted of 14 items covering 7 primary indicators of practicality: ease of use, clarity of instructions, smoothness of system performance in terms of navigation and interface, efficiency of learning time (not being too long or boring), relevance to course content, perceived usefulness, and intent to reuse the application. After completing the learning activities using the EconoVerse application, a

questionnaire was administered to 60 students from the Management and Marketing study programs. The data were converted into percentage scores, with a threshold of 70% used to determine whether the system was considered practical.

Table 9: Practicality (usability) test results

No.	Indicator	Number of items	Practicality score (%)	Category
1	Ease of use	2	91.20	Practical
2	Clarity of instructions	2	89.50	Practical
3	System performance smoothness	2	88.70	Practical
4	Efficiency of learning time	2	90.10	Practical
5	Relevance to course content	2	92.40	Practical
6	Perceived usefulness	2	93.10	Practical
7	Intention to reuse the application	2	94.00	Practical
	Total	14	91.86	Practical

The results of the practicality test showed high usability across all indicators assessed for the EconoVerse system. The highest score was obtained for intention to reuse the application (94%), indicating that students were strongly interested in using the platform again to learn about finance and develop entrepreneurial skills. Perceived usefulness and relevance to course design also received high scores, indicating that the system supported learning outcomes that were closely aligned with learners' needs. The items assessing ease of use, clarity of instructions, system performance, and time efficiency scored between 88% and 91%, indicating that the system provided accessible, stable, and efficient learning support. The overall practicality score of 91.86% was also higher than the minimum cut-off of 70%, demonstrating that the EconoVerse system was considered practical for implementation as a learning tool in a university environment.

4.6 Effectiveness Test Results

4.6.1 Transformative financial literacy

A pretest-posttest questionnaire was administered to 60 students from the Management and Marketing study programs to evaluate the efficacy of the EconoVerse system in improving students' transformative financial literacy. The instrument assessed three aspects of transformative financial literacy: (1) financial knowledge, (2) financial awareness, and (3) financial behavior. A paired-samples *t*-test was used to compare the pretest and posttest scores, while a gain score was calculated to determine the extent of improvement following the use of the learning system (Table 10; Figure 6).

The results of the paired-samples *t*-test revealed statistically significant gains across the dimensions of transformative financial literacy after the students used the EconoVerse learning system. A large effect was observed for financial knowledge ($t = 10.92, p 1.30$), demonstrating that the EconoVerse system had a significant effect on improving students' financial competencies. These findings

suggest that mobile learning, financial simulations, and scenario-based decision-making can collectively facilitate changes in knowledge acquisition and skills development in financial literacy. In conclusion, the results indicate that the EconoVerse Android-based seamless mobile learning system can be an effective means of enhancing students' transformative financial literacy in terms of their ability to comprehend, reason about, and apply financial content in context.

Table 10: Paired samples *t*-test results for transformative financial literacy

No	Indicator	Pretest (mean ± SD)	Posttest (mean ± SD)	Gain	<i>t</i> - statistic	Sig. (<i>p</i>)	Cohen's <i>d</i> (dz)	Effect size
1	Financial knowledge	69.5 ± 8.1	87.8 ± 6.9	18.3	10.92	0.000	1.38	Large
2	Financial awareness	66.8 ± 8.5	85.6 ± 7.3	18.8	11.10	0.000	1.41	Large
3	Financial behavior	64.2 ± 8.9	84.9 ± 7.6	20.7	11.75	0.000	1.48	Large
Overall transformative financial literacy		66.8 ± 8.5	86.1 ± 7.3	19.3	11.26	0.000	1.42	Large

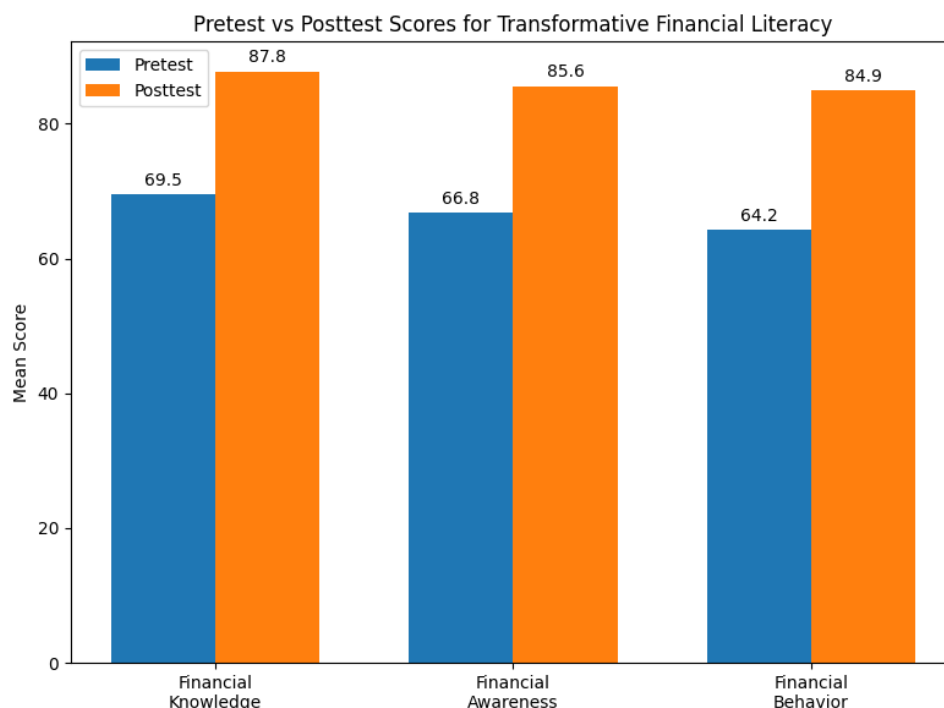


Figure 6: Pretest and posttest scores of transformative financial literacies

4.6.2 Entrepreneurial readiness

A pretest-posttest questionnaire was used to assess the effectiveness of the EconoVerse Android-based seamless mobile learning system on students' entrepreneurial readiness. The questionnaire was administered to 60 students from the Management and Marketing study programs. The instrument captured

three main dimensions of entrepreneurial readiness: entrepreneurial intention, decision-making ability, and business readiness. A paired-samples *t*-test was used to compare the pretest and posttest scores, while gain scores were calculated to determine the extent of improvement following implementation of the learning system.

Table 11: Paired-samples *t*-test results for entrepreneurial readiness

No	Indicator	Pretest (mean ± SD)	Posttest (mean ± SD)	Gain	<i>t</i> - statistic	Sig. (<i>p</i>)	Cohen's <i>d</i> (dz)	Effect size
1	Entrepreneurial intention	68.7 ± 8.0	86.9 ± 6.9	18.2	10.76	0.000	1.35	Large
2	Decision- making ability	65.9 ± 8.4	85.2 ± 7.2	19.3	11.18	0.000	1.41	Large
3	Business readiness	63.5 ± 8.8	84.3 ± 7.5	20.8	11.82	0.000	1.49	Large
Overall entrepreneurial readiness		66.0 ± 8.4	85.5 ± 7.2	19.5	11.25	0.000	1.42	Large

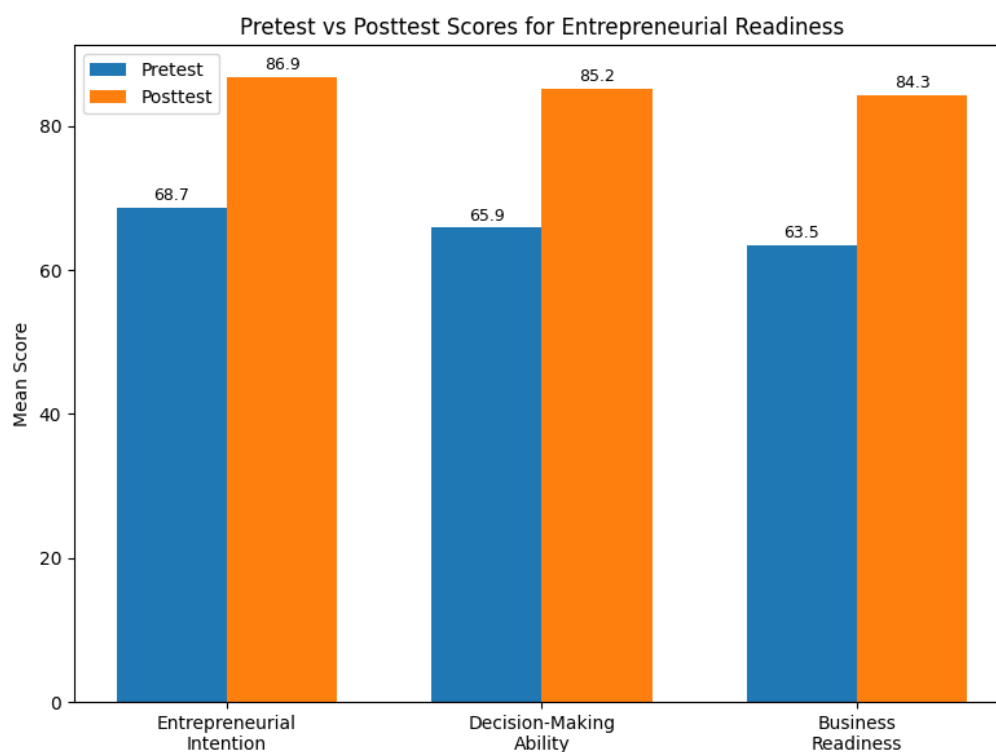


Figure 7: Pretest and posttest scores for entrepreneurial readiness

The results of the paired-samples *t*-test indicated a statistically significant improvement across all aspects of entrepreneurial readiness after students used the EconoVerse learning system. The results showed substantial gains in scores from pretest to posttest for entrepreneurial intention ($t = 10.76$, $p = 0.000$), indicating that the EconoVerse system was effective in developing students' entrepreneurial competencies. These results indicate that the integration of financial simulations,

decision-making scenarios, and adaptive learning features supported the development of entrepreneurship-related competencies. Overall, the findings show that the EconoVerse Android-based seamless mobile learning system significantly improved students' entrepreneurial readiness, particularly in terms of entrepreneurial intention, strategic decision-making ability, and business readiness.

5. Discussion

The results of this research demonstrate that developing the EconoVerse platform as an Android-based transdisciplinary seamless mobile learning system had a positive effect on students' transformative financial literacy and entrepreneurial readiness. The improvements across the domains of knowledge, awareness, and behavior support previous findings suggesting that experiential learning with technology-enhanced training can contribute to meaningful learning changes. These findings align with TLT, which highlights practical engagement, critical reflection, experiential learning, and action as important elements in real-world learning (Lange, 2019; Priya et al., 2024; Stansberry, 2023). Thus, EconoVerse not only serves as a serving platform for delivering content but also provides an interactive learning environment that bridges the gap between abstract concepts and their application in real-life contexts.

The success of EconoVerse reinforces the importance of effective mobile educational technology in creating flexible, adaptive, and continuous learning experiences. The combination of traditional theoretical knowledge with real-world financial simulations and scenario-based decision-making, together with the convenience of accessing learning activities across different times and locations, addresses many of the learning needs of students. The results are consistent with previous literature indicating that mobile learning can enhance learner engagement, accessibility, and learning effectiveness in entrepreneurship education (Hossain et al., 2021; Naveed et al., 2023; Noguera et al., 2026; Wong et al., 2021). In addition, the integration of digital learning technologies has been shown to help bridge the gap between theoretical knowledge and the practical skills required in modern business environments (Chen et al., 2021; Prokopenko et al., 2024; Zahra & Mudambi, 2025).

Moreover, the patterns of student engagement identified in the EconoVerse platform can be related to findings from learning analytics and Big Data studies in higher education. Research conducted in e-learning environments using platforms such as Blackboard and Pyramid indicates that student interactions are dynamic, with considerable temporal variation and fluctuations in the duration of engagement throughout the day. Studies have shown that morning hours are among the most common periods for educational activities, when access to mobile applications can increase interaction with course content and elements. These findings support the development of EconoVerse as a seamless Android application that aligns with students' inclination to use mobile devices for learning during periods of higher engagement (Alghamdi & Alhaykan, 2025).

The larger gain in the financial behavior dimension indicates that learning through simulations and scenarios in EconoVerse may have contributed to changes in students' financial mindsets and behaviors. This suggests that interactive and experiential learning approaches can support financial learning beyond traditional knowledge-based instruction. The results are consistent with the principles underlying transformative financial literacy, which extends beyond cognitive skill development to include responsible financial practices and decision-making skills (Brunstein et al., 2020; Ianole-Calin et al., 2021; Johari, 2025; Tavares & Almeida, 2025). By incorporating cognitive, affective, and behavioral components within a single digital learning environment, EconoVerse provides comprehensive financial learning experience.

With regard to entrepreneurial readiness, the results showed positive changes in entrepreneurial intention, decision-making ability, and readiness to start a business. This suggests that combining financial simulations, real-life scenarios, and entrepreneurship challenges within the EconoVerse platform can help prepare students to participate in entrepreneurial activities. These findings are consistent with previous research showing that factors associated with entrepreneurial readiness among university students include financial literacy and the use of digital learning technologies (Hasan et al., 2024; Kamila & Fahlia, 2025; Pandey & Chadha, 2026; Wahhab et al., 2025). Furthermore, mobile-based learning applications have been shown to support the development of business-related knowledge and non-cognitive skills that are important for entrepreneurial success (Med & Lukyamuzi, 2019; Moein et al., 2015; Umami et al., 2023; Wu et al., 2019).

In conclusion, the findings of this research show that seamless mobile learning, transformative financial literacy, and experiential entrepreneurship education can contribute to developing students' skills and competencies for the digital age. In addition to enhancing engagement and learning outcomes, the EconoVerse platform also supports behavioral change and entrepreneurial readiness. The findings have theoretical and practical implications for the development of technology-enhanced learning models that respond to the demands of the digital economy and Industry 4.0.

6. Conclusion

Based on the findings of this study, it can be concluded that the Android-based seamless mobile learning system, EconoVerse, is valid, practical, and effective in improving students' transformative financial literacy and entrepreneurial readiness. By combining principles of transformative learning with a mobile learning environment based on experiential learning and enquiry-based pedagogy, the system supports learners not only in developing foundational knowledge of financial concepts but also in applying this knowledge to real-life decision-making situations. The findings show that all dimensions of financial literacy and entrepreneurial readiness have improved, with large effect sizes. The system incorporates interactive features, including simulation models, decision-making scenarios, and gamification, which promote student engagement and support higher-level learning and entrepreneurial readiness. Thus, EconoVerse

provides an appropriate learning medium for supporting the development of skills needed to navigate an increasingly digitalized economy.

The significance of this research extends beyond its national and institutional context and may have relevance for higher education systems internationally that are facing emerging challenges in economic education in the 21st century. First, the EconoVerse digital architecture provides a prototype for a scalable Android-based mobile learning model that links lecturer-led instruction with students' independent learning activities. This framework could potentially be adapted by institutions facing similar constraints, including limited time for teaching entrepreneurship, which involves complex and behavior-based learning.

Second, the study provides a potential cross-cultural reference for assessing the development of financial and entrepreneurial competencies in digital learning environments by extending empirical attention beyond financial literacy as a knowledge-based construct to include transformative financial behaviors and entrepreneurial readiness. Thus, the methodological procedures and validation measures presented in this study provide a basis for further research and replication by international researchers and instructional designers seeking to develop technology-enhanced approaches to financial and entrepreneurship education.

7. Recommendations

Future research should investigate EconoVerse with larger and more diverse samples and experimental designs that include control groups to further substantiate the generalizability of the findings. Future system development could incorporate more advanced functionalities, such as AI-enabled adaptive learning, real-time financial data integration, and diverse collaborative business simulation environments. Educators could integrate EconoVerse into traditional financial and entrepreneurship courses to provide students with further opportunities to apply their skills in practical contexts. In addition, policymakers and educational institutions could promote technology- and mobile-enriched learning systems at the school level to develop financial literacy and entrepreneurial readiness, which are important for preparing students for the changing global economy.

Although the results of EconoVerse are encouraging, several methodological limitations provide opportunities for further research. First, the one-group pretest–posttest design without a control group limits the internal validity and causal inference regarding the effectiveness of the platform. Given the multicomponent nature of the intervention and the potential for confounding factors, future studies should employ true experimental or randomized controlled trial (RCT) designs. Second, although the current sample of 60 undergraduate students provided preliminary findings, a larger sample would be more appropriate for further examination of the psychometric properties of the measurement instruments using CFA. Future research should therefore replicate the study with larger and more diverse samples to provide stronger evidence regarding the validity and reliability of the assessment instruments. Finally,

purposive sampling introduces the possibility of selection bias, as participants may have already been more prepared to use digital technology. Future research should consider probability sampling across institutions and geographic regions to reduce selection bias and increase the transferability of the findings to broader higher education settings.

8. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors. In addition, this research received no specific grant or financial support from any funding agency in the public, commercial, or not-for-profit sectors.

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