AI-Driven Gamification in Virtual Worlds: A Conceptual Framework for Digital Entrepreneurship Competency Development

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Abstract

The rapid digital transformation of the 21st century has redefined entrepreneurship, demanding new competencies that extend beyond traditional business knowledge. This study introduces the AI-Driven Gamification in Virtual Worlds for Digital Entrepreneurship Competency (AIDGAIDGVW-DEC) framework, which integrates artificial intelligence, gamification, and immersive virtual world technologies to foster entrepreneurial mindsets and digital skills. Employing a qualitative documentary research design, the framework was developed through a synthesis of scholarly literature and subsequently validated by a panel of five experts in educational technology, entrepreneurship, and learning sciences. The framework consists of three interconnected components: inputs (digital entrepreneurship content, gamification elements, AI-powered personalization, and virtual world technologies), learning processes (VR game-based simulations, AI behavior analysis, gamification engagement, and continuous assessment), and outputs (entrepreneurial competencies, motivation, practical application of knowledge, and behavioral change). Expert evaluation using a 5-point Likert scale confirmed the framework's high appropriateness across all dimensions, with mean scores ranging from 4.60 to 4.90, indicating "absolutely appropriate" levels. Notably, theoretical alignment achieved the highest rating ($M = 4.90$, $SD = 0.45$), underscoring the framework's strong conceptual foundation. The findings highlight both the theoretical and practical contributions of the framework. Theoretically, it synthesizes gamification, immersive learning, and AI-driven personalization into a cohesive pedagogical model. Practically, it offers educators a replicable, flexible tool for designing innovative curricula that enhance learner engagement and entrepreneurial readiness. Future research should focus on empirical implementation, scalability, and cross-cultural applicability to further refine the framework and strengthen its generalizability. The findings indicate the framework's strong conceptual grounding and expert-validated appropriateness. While promising, the framework requires future empirical testing to determine its effectiveness in real educational contexts. This study therefore provides a foundational contribution for guiding further instructional design and research in digital entrepreneurship education.

Keywords: artificial intelligence, gamification, virtual worlds, digital entrepreneurship competency, conceptual framework

1. Introduction

The digital revolution of the 21st century has profoundly reshaped how people live, work, and learn, with entrepreneurship undergoing a significant transformation. Fosu (2020) notes that digital platforms are increasingly replacing traditional business models, while Goeser and Williams (2021) emphasize that entrepreneurs must now cultivate digital, cognitive, and social competencies to succeed in this evolving landscape. In response, Dillenbourg et al. (2020) argue that education must embrace innovative approaches that foster entrepreneurial mindsets, and Chin (2024) highlights the importance of designing authentic, technology-enhanced learning experiences to prepare students for real-world complexity. Virtual world learning environments (VWLEs) have emerged as a promising response to this educational challenge. Safitri and Yulhendri (2023) demonstrate that immersive virtual spaces enable

learners to simulate entrepreneurial ecosystems, experiment with business strategies, and respond to customer feedback in a risk-free environment. Similarly, Goeser and Williams (2021) observe that such environments promote opportunity recognition, adaptability, and creativity. Beyond technical skills, Damaševičius and Sidekerskiene (2024) emphasize the potential of VWLEs to enhance collaboration, negotiation, and leadership competencies that are often underemphasized in traditional curricula. By engaging in problem-based scenarios and role-playing through avatars, students are better able to bridge the gap between theoretical knowledge and entrepreneurial practice.

Artificial Intelligence (AI) significantly enhances the potential of VWLEs. Hashmi (2023) and Göde and Kalkan (2023) highlight how AI enables personalized feedback, adaptive challenges, and dynamic scaffolding to support entrepreneurial learning. Yadav et al. (2023) further demonstrate the role of AI-driven non-player characters (NPCs) acting as customers, investors, or mentors, thereby fostering authentic interactions and supporting learners' development of strategic planning, judgment, and decision-making under uncertainty. Complementing this, gamification provides powerful mechanisms for motivation and persistence. Christopoulos and Mystakidis (2023) illustrate how points, challenges, and feedback loops can engage learners, while Zhou (2024) emphasizes the role of gamification in cultivating adaptability and initiative. Mao and Lucas (2024) argue that such game mechanics reinforce learner agency and experimentation, and Maryana et al. (2024) confirm that gamified structures mirror entrepreneurial incentives such as profit, recognition, and mastery. Collectively, these studies highlight the capacity of gamification to transform passive instruction into active, goal-oriented learning experiences.

In response to these opportunities, the present study introduces the AIDGAIDGVW-DEC Conceptual Framework, a gamified virtual world learning framework that integrates AI, gamification, and immersive platforms (e.g., Roblox) to foster Digital Entrepreneurship Competencies (DEC) among upper secondary students. The framework engages learners in entrepreneurial processes, including opportunity recognition, risk assessment, problem-solving, and customer engagement, within experiential, feedback-rich, and game-based learning environments. The overarching aim of this study is to synthesise and present the conceptual framework of the AIDGAIDGVW-DEC as a foundation for designing innovative virtual learning environments that advance digital entrepreneurship education.

To address ongoing fragmentation in digital entrepreneurship education, this study introduces the AIDGAIDGVW-DEC conceptual framework, developed through documentary analysis and expert validation. The framework integrates AI-driven personalisation, gamified engagement, and immersive virtual world technologies into a unified structure. The purpose of this study is to articulate the framework's components, theoretical foundations, and potential applications, thereby providing a conceptual basis for future instructional design and empirical research.

2. Method

This study adopted a qualitative documentary research design to synthesise and validate the AIDGAIDGVW-DEC, a conceptual framework for gamified virtual world learning environments aimed at enhancing digital entrepreneurship competencies. The methodology was structured in two phases: framework development and expert validation.

2.1 Phase 1: Framework Development

In the first phase, a qualitative documentary research approach was employed to develop the AIDGAIDGVW-DEC conceptual framework. Data collection involved an AI-assisted systematic search using the Consensus platform to ensure comprehensive coverage of relevant literature. The search strategy utilized specific keywords aligned with the study's four key domains: "Digital Entrepreneurship Competencies," "Gamification in Education," "Artificial Intelligence in Adaptive Learning," and "Virtual World Learning Environments."

To ensure the framework reflects the most current technological advancements and pedagogical shifts, the inclusion criteria were strictly defined to select peer-reviewed articles and empirical studies published between 2019 and 2025. The selection process prioritized studies that provided empirical evidence on the integration of AI and gamification in immersive settings. Consequently, a total of 11 key studies were selected for in-depth synthesis (e.g., Xin & Xiaohong, 2023; Lampropoulos & Kinshuk, 2024; Ghanbaripour et al., 2024). These sources were analyzed to identify essential components, design principles, and interrelationships, which were systematically integrated to construct the AIDGAIDGVW-DEC framework.

2.2 Phase 2: Framework Validation

In the second phase, the appropriateness of the AIDGAIDGVW-DEC framework was evaluated by a panel of experts. A panel of five experts in the fields of education technology, entrepreneurship, and learning sciences reviewed the

framework using a 5-point Likert scale to determine its suitability in terms of clarity, relevance, and applicability. Data from the evaluation were analyzed using the mean ($\bar{x}$) as the primary indicator of suitability, with interpretations guided by established benchmarks.

Table 1. Interpretation Criteria for Expert Evaluation

Mean Score ($\bar{x}$)	Interpretation
4.50 – 5.00	Absolutely Appropriate
3.50 – 4.49	Appropriate
2.50 – 3.49	Neutral
1.50 – 2.49	Inappropriate
1.00 – 1.49	Absolutely Inappropriate

Together, these two phases provided a rigorous methodological pathway for constructing and validating the AIDGAIDGVW-DEC, ensuring both theoretical grounding and empirical evidence of its robustness. This methodological design established the foundation for the results and discussion presented in the subsequent sections.

3. Results

Stage 1. Conceptual Structure of the Framework

To ensure conceptual clarity, this section presents only the structure, logic, and source origins of the AIDGAIDGVW-DEC framework. All theoretical explanations and prior research have been presented in the Literature Review. The references cited here indicate the documentary sources from which individual components of the framework were derived, not theoretical justification.

The core components of the framework are summarised in Table 2 and illustrated in Figure 1, showing the relationships among inputs, learning processes, mediating factors, and outputs. These elements were synthesized from prior studies on AI-driven learning, gamification, and virtual world environments, which collectively informed the architectural design of the AIDGAIDGVW-DEC framework.

The framework integrates key constructs drawn from Xin and Xiaohong (2023), Isabelle (2020), Lampropoulos and Kinshuk (2024), and other foundational works identified during the documentary analysis. The structure consists of three main dimensions:

- Input, adapted from prior studies on digital entrepreneurship content, gamification structures, AI personalization, and virtual world technologies;
- Learning Processes, systematically organized into four phases synthesised from models of immersive learning and adaptive gamified engagement; and
- Output, reflecting entrepreneurial competencies and behavioural outcomes documented across the reviewed literature.

The AIDGAIDGVW-DEC integrates gamification, virtual world learning environments (VWLEs), and artificial intelligence (AI) to enhance entrepreneurial competencies. The framework is organized around three primary dimensions: Input, which encompasses entrepreneurship content, gamification elements, AI-based personalization, and virtual technologies; Learning Processes, which detail the operationalization of these inputs through immersive simulations, adaptive support, and gamified tasks; and Output, which extends beyond knowledge acquisition to include motivation, entrepreneurial mindset, decision-making ability, and self-efficacy.

Table 2. Synthesis Table of the Conceptual Framework

Component	Sub-component	Key Elements	Source of Component (Documentary Basis)
INPUT	Digital Entrepreneurship Content	- Digital Policy Knowledge & Regulatory Framework - Entrepreneurial Thinking & Innovation Mindset - Digital Business Planning & Strategy Development - Self-Efficacy Development & Confidence Building	(Xin & Xiaohong, 2023; Primario et al., 2024)
	Gamification Elements	- Points & Rewards System for Achievement Recognition - Achievement Badges & Milestone Tracking - Leaderboard System & Competitive Rankings - Instant Feedback & Real-time Response - Fun & Enjoyment Through Interactive Design	(Xin & Xiaohong, 2023; Isabelle, 2020; Lampropoulos & Kinshuk, 2024; Acosta-Medina et al., 2021)
	Virtual World Technology	- 3D/VR Environment & Spatial Computing - Business Simulation & Scenario Modeling - VR Interaction & Collaborative Virtual Workspaces - Realistic Experience Creation & Immersive Learning	(Isabelle, 2020; Lampropoulos & Kinshuk, 2024)
	Al-Powered Personalization	- Learner Behavior Analysis & Pattern Recognition - Personalized Content Adaptation & Dynamic Customization - Automated Feedback & Intelligent Recommendations - Learning Progress Tracking & Performance Analytics	(Lampropoulos & Kinshuk, 2024; Jantakoon et al., 2025)
LEARNING PROCESS	Phase 1: VR Game-Based Learning	- Virtual Reality Scenario Simulation - Group Competition and Collaboration - Problem Solving and Critical Thinking Through Games - Using Gamification Mechanics for Motivation - Interactive Content and Challenge Presentation	(Benvenuti et al., 2023; Zhan et al., 2024; Ghanbaripour et al., 2024)
	Phase 2: Al Behavior Analysis	- AI Analyzes Learner Behavior and Adapts Content/Activities - Automated Personalized Feedback and Recommendations - Continuous Learning Progress Tracking and Assessment	(Benvenuti et al., 2023; Xin & Xiaohong, 2023)
	Phase 3: Gamification Engagement	- Points, Badges, and Leaderboards to Stimulate Participation - Activity Design Focused on Fun and Challenge - Promoting Teamwork and Communication Skills	(Xin & Xiaohong, 2023; Zhan et al., 2024; Ghanbaripour et al., 2024)
	Phase 4: Continuous Assessment	- Learning Assessment During and After Activities - Learning Reflection and Real-World Application - Learning Process Improvement Based on Assessment Results	(Benvenuti et al., 2023; Ghanbaripour et al., 2024)
OUTPUT	Digital Entrepreneurship Competency Development	- Increased intention and motivation to become digital entrepreneurs - VR and gamification impact decision-making and confidence in starting businesses - Enhanced entrepreneurial thinking and strategic mindset	(Xin & Xiaohong, 2023; Lampropoulos & Kinshuk, 2024; Ghanbaripour et al., 2024; Ronaghi & Forouharfar, 2024)
	Increased Motivation & Engagement	- Increased motivation, interest, and active participation in learning - Creation of fun and challenging experiences that enhance engagement - Enhanced satisfaction and curiosity toward learning new concepts	(Xin & Xiaohong, 2023; Lampropoulos & Kinshuk, 2024; Ghanbaripour et al., 2024)
	Practical Knowledge Application	- Development of essential skills for working in the digital era - Increased employment opportunities and job market competitiveness - AI and gamification enable accurate data analysis and business decision-making - Enhanced data utilization and technology application skills	(Lampropoulos & Kinshuk, 2024; Ghanbaripour et al., 2024; Han & Najord, 2024)
	Behavioral & Attitude Change	- AI and gamification enhance analytical thinking and business decision accuracy - Advanced data processing and technology integration capabilities - Enhanced problem-solving skills and strategic decision-making abilities	(Han & Najord, 2024)

The construction of the AIDGAIDGVW-DEC framework synthesised 11 key studies published between 2019 and 2025, particularly works on AI-driven personalization (Göde & Kalkan, 2023; Hashmi, 2023), immersive virtual world learning (Lampropoulos & Kinshuk, 2024), and gamified entrepreneurship education (Xin & Xiaohong, 2023). These documentary sources informed the integration of AI, gamification, and virtual environments into a unified framework for digital entrepreneurship competency development.

The framework comprises three core components that were synthesised from the documentary analysis. The Input dimension incorporates foundational knowledge, entrepreneurial thinking, and self-efficacy elements, drawing on foundational work in digital entrepreneurship and AI-supported learning (Busel & Polupan, 2022). The Learning Process dimension was shaped by documented models of immersive interaction and gamified engagement, which informed the sequencing of virtual tasks and game mechanics (Badilla-Quintana & Sandoval-Henríquez, 2021; Lampropoulos & Kinshuk, 2024). The Output dimension reflects established indicators of entrepreneurial competency development, derived from prior research highlighting practical skill formation, entrepreneurial mindset development, and behavioural transformation (Grivokostopoulou et al., 2019; Mao & Lucas, 2024; Zhou, 2024).

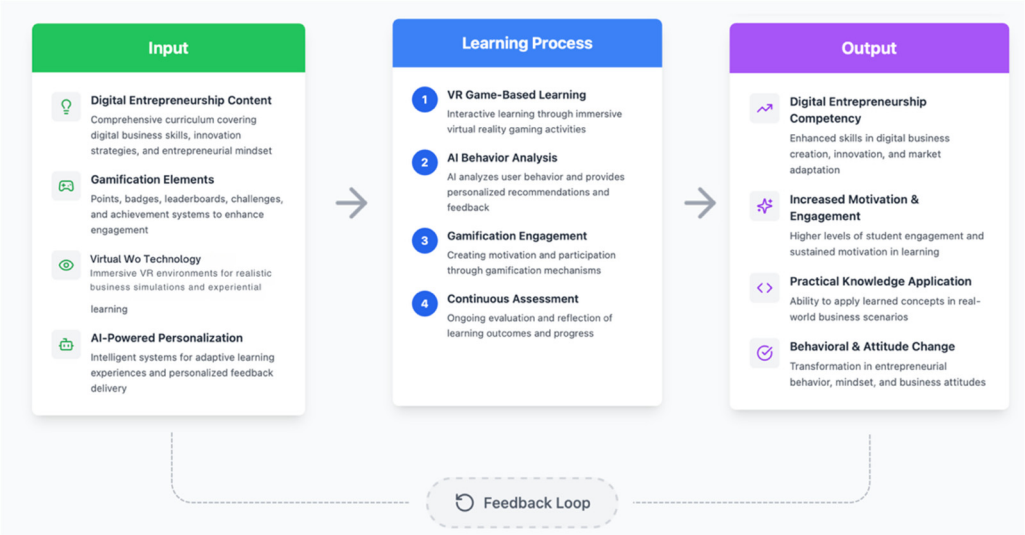

Figure 1. AI-Driven Gamification in Virtual Worlds: A Conceptual Framework for Digital Entrepreneurship Competency Development *(*AIDGAIDGVW-DEC)

3.1 Input Components

The model begins with four core input components:

1. Entrepreneurship Competency Content – Covering digital business knowledge, entrepreneurial mindset, innovation, and decision-making skills.
2. Gamification Elements – Including points, badges, quests, and real-time feedback to drive engagement and motivation.
3. Virtual World Technologies – Providing immersive 3D environments for risk-free business simulation, allowing learners to interact, build, and test ideas.
4. Artificial Intelligence – Supporting personalised learning through behavioural analysis, adaptive feedback, and learner-specific content (Xin & Xiaohong, 2023; Grivokostopoulou et al., 2019).

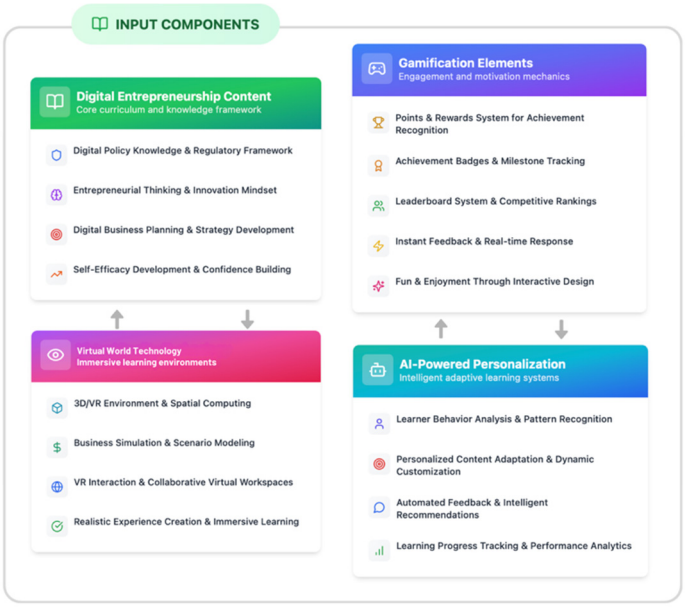

Figure 2. The Input Components of This Conceptual Framework

3.1.1 Digital Entrepreneurship

This paper examines the key components of successful digital entrepreneurship, which involves leveraging digital technologies to create or enhance businesses. Digital entrepreneurship has become increasingly relevant as technological advancements reshape business models and create new opportunities across sectors. Four key elements are crucial for success. Digital policy knowledge and an understanding of regulatory frameworks are essential for operational compliance (Zhao & Collier, 2016). An entrepreneurial and innovative mindset is vital for adapting to technological change and market trends (Ali et al., 2023). Furthermore, strategic business planning is necessary to develop robust business models and safeguard intellectual property (Whittington, 2018). Finally, self-efficacy development enhances confidence to overcome challenges and capitalize on opportunities (Anim-Yeboah et al., 2020). Collectively, these elements form the foundational competency base upon which digital entrepreneurs build the skills required to navigate dynamic, technology-driven environments.

3.1.2 Gamification Elements

Gamification elements are increasingly applied in education to enhance engagement, motivation, and performance. As digital learning environments evolve, these mechanics play an essential role in transforming passive instruction into active, goal-oriented participation. Points, rewards, and badges offer tangible recognition for achievement, track progress, and motivate learners (Mao & Lucas, 2024). The use of leaderboards introduces competition, which significantly drives improvement (Pahlevi & Mulyati, 2024; Qudsi, 2024). Furthermore, instant feedback provides real-time reinforcement that sustains engagement. The integration of interactive design fosters enjoyment, creativity, and problem-solving, enriching the learning environment (Putra et al., 2024; Qudsi, 2024). When combined, these elements not only sustain learner interest but also promote persistence, collaboration, and positive learning behaviours. These elements collectively create a stimulating learning ecosystem.

3.1.3 Virtual World Technology

Virtual world technology integrates key components to provide realistic and interactive experiences across various fields. These environments have become increasingly significant as digital learning ecosystems seek to replicate authentic, real-world experiences through immersive virtual design. 3D/VR environments and spatial computing enable real-time avatar interaction and navigation (Bauman & Rivers, 2015). Business simulations replicate real-world scenarios, supporting experiential learning in a risk-free setting (Ketron et al., 2024; Dad et al., 2016). Collaborative virtual workspaces enhance remote communication and teamwork (Avanzato, 2013). Finally, immersive learning designs foster active engagement and skill practice, improving learner focus and emotional connection to the content (Mahmoudi-Dehaki & Nasr-Esfahani, 2024; Ketron et al., 2024). Together, these technological affordances enable learners to explore, experiment, and problem-solve in highly interactive contexts

that mirror the complexities of authentic professional environments. These elements collectively expand the technology's application in education and business.

3.1.4 AI-Powered Personalization

AI-powered personalization tailors learning experiences to individual learners by leveraging several key components. As digital education shifts toward more flexible and learner-centred models, AI-driven systems play an increasingly essential role in delivering instruction that adapts to diverse needs. Learner behavior analysis and pattern recognition are used to create adaptive learning environments (Kaswan et al., 2024; Castro et al., 2024). Personalized content adaptation and dynamic customization ensure that learning materials are relevant to individual needs, thereby improving comprehension and retention (Apetorgbor et al., 2024; Jian, 2023; Dunusinghe et al., 2023). Automated feedback and intelligent recommendations provide real-time guidance (Katiyar et al., 2024). Finally, performance analytics track progress and predict future needs, enabling targeted interventions (Shete et al., 2024). Collectively, these capabilities support a more responsive and efficient learning process, ensuring that each learner receives support aligned with their current progress and future development. This approach makes learning more effective and impactful.

3.2 Learning Process

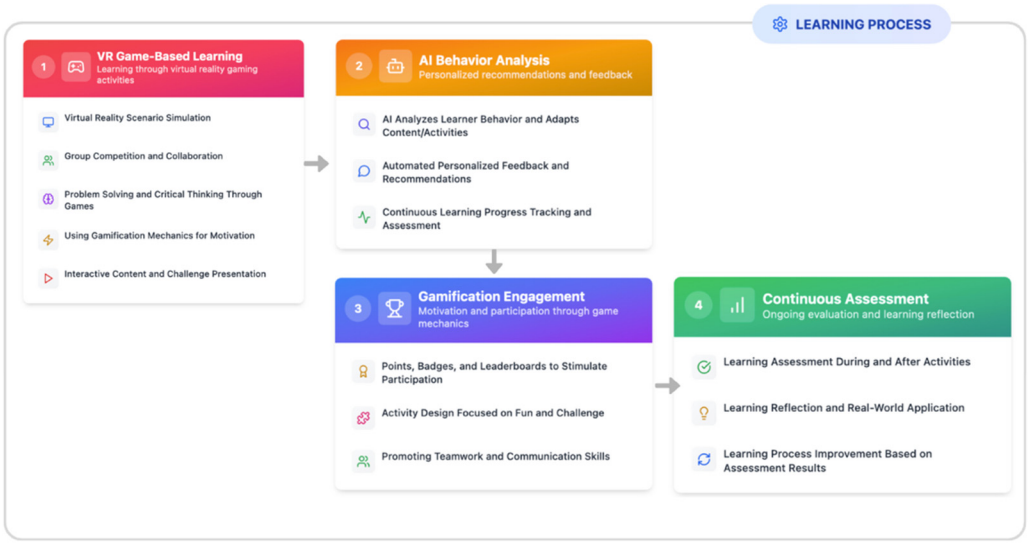

Figure 3. The Learning Process of This Conceptual Framework

3.2.1 Stage 1: VR Game-Based Learning

VR game-based learning uses immersive experiences to develop problem-solving, critical thinking, and collaboration skills. As learners navigate virtual spaces, they engage in situated learning that mirrors authentic contexts and encourages active experimentation. VR simulations enhance both theoretical and practical understanding, particularly for complex concepts (Villegas-Ch et al., 2024). Gamified elements, such as leaderboards, stimulate both competition and teamwork (Zairon et al., 2023). Interactive games and challenging scenarios foster analytical and problem-solving skills (Pressman et al., 2022). This approach transforms learners into active participants, utilizing mechanisms such as points and rewards to sustain motivation and deepen engagement with the content (Lampropoulos & Kinshuk, 2024). By merging immersion with gameplay mechanics, VR-based learning creates high-impact learning environments that strengthen cognitive and interpersonal skills. The integration of these elements creates effective and engaging learning environments.

3.2.2 Stage 2: AI Behavior Analysis

AI is integrated into education to personalize learning experiences. It analyzes learner behavior and performance data to create personalized profiles, enabling the creation of adaptive learning environments (Akavova, 2023). Through this continuous data-driven analysis, AI systems are able to detect learning patterns, anticipate difficulties, and adjust instructional pathways accordingly. Automated feedback and intelligent recommendations, AI systems support individualized learning at each learner’s pace and need. Furthermore, AI enables continuous assessment and progress

tracking, providing accurate evaluations and enabling timely interventions (Zhang, 2024; Velasco, 2023; Vashishth et al., 2024). These capabilities ensure that learners receive tailored guidance, reinforcing strengths while addressing specific learning gaps. This approach enhances educational outcomes by making learning more effective and responsive.

3.2.3 Stage 3: Gamification Engagement

Gamification applies game design principles to learning to enhance engagement, motivation, and outcomes. By embedding game-like structures into learning tasks, educators can transform routine activities into meaningful challenges that sustain interest. Points, badges, and leaderboards are used to track progress, recognize achievement, and stimulate participation, driving learners toward continuous improvement (Kara & Russell, 2024; Qudsi, 2024; Putra et al., 2024; Kumar et al., 2024). The design of these activities is crucial, requiring a balance of fun and challenge to sustain engagement and stimulate problem-solving skills (Kumar et al., 2024; Qudsi, 2024). Additionally, gamification promotes teamwork and communication by requiring participants to collaborate on shared tasks, fostering social interaction and a sense of belonging within the group (Mitchell & Co, 2024; Kumar et al., 2024; Smirani & Yamani, 2024). When implemented effectively, gamification not only motivates individual learners but also cultivates collaborative learning cultures that support deeper understanding and persistence.

3.2.4 Stage 4: Continuous Assessment

Continuous assessment involves the ongoing evaluation of student learning to improve outcomes beyond simple progress measurement. This process makes assessment an integral part of learning rather than a separate, end-of-unit activity. It provides regular feedback to help learners identify strengths and weaknesses and deepens understanding by encouraging self-reflection (Olasoji, 2016; Garcia & Cuello, 2009; Hussey, 2017). Furthermore, it supports the application of knowledge in real-world contexts, strengthening critical analytical, collaborative, and communication skills vital for professional practice (Reimagined Continuous Assessment..., 2023; Didenko & Filatova, 2017). By utilizing assessment data, educators can continuously improve the curriculum and instructional methods. This not only enhances teaching quality but also guides educational policy, ultimately deepening learning and improving student outcomes across disciplines (Mahalingam & Blumberg, 2019; Carrillo-de-la-Peña & Pérez, 2012; Muskin & Educación, 2017). Overall, continuous assessment ensures that learning remains adaptive, reflective, and aligned with long-term competency development.

3.3 Output Component

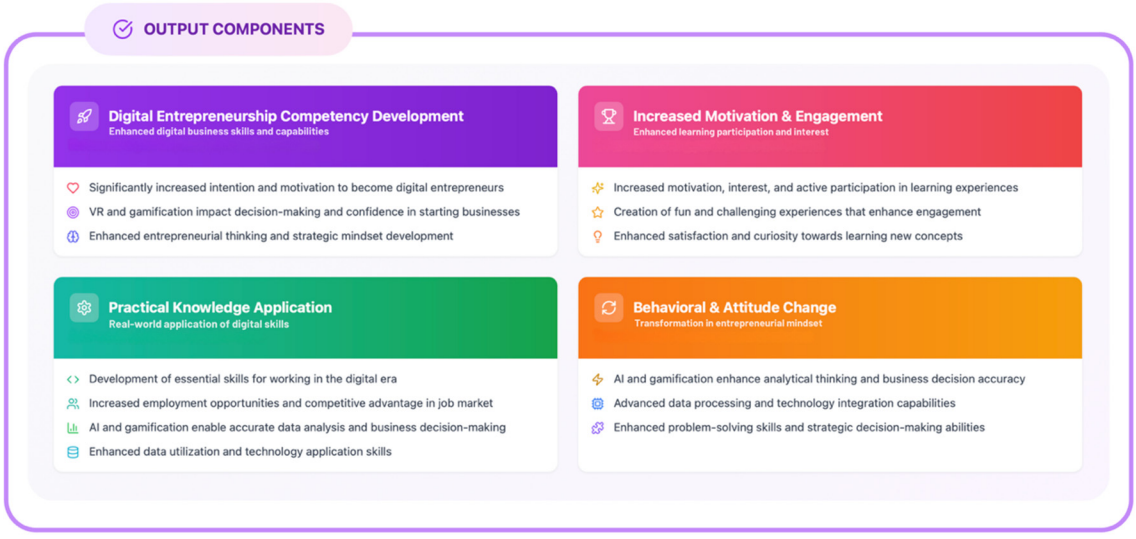

Figure 4. The Output Components of This Conceptual Framework

The output components of this framework focus on the tangible outcomes emerging from the learning process. These encompass not only the knowledge and skills acquired by learners but also changes in attitudes, behaviors, and the ability to apply learning in real-world digital entrepreneurship contexts. Such outcomes reflect the shift from traditional rote learning toward competency-based development, where learners demonstrate not just understanding

but the capacity to act effectively in digital environments. The outputs are designed to align with 21st-century demands, fostering sustained motivation, active engagement, and the effective development of digital entrepreneurship competencies. By integrating cognitive, affective, and practical dimensions, the framework ensures that learners are equipped with holistic competencies that support long-term success in technology-driven entrepreneurial ecosystems.

3.3.1 Digital Entrepreneurship Competency Development

Developing digital entrepreneurship competencies hinges on a combination of key factors. First, entrepreneurial intention and motivation are significantly enhanced by digital capabilities and self-efficacy (Bachmann et al., 2024; Gudi et al., 2024). This is further supported by a mindset that values tracking technology trends (Ali et al., 2023). Such cognitive and motivational foundations enable learners to respond proactively to emerging digital opportunities. Second, the use of VR and gamification is crucial for boosting learners' confidence and decision-making by providing authentic, simulated business challenges (Ronaghi & Forouharfar, 2024; Grivokostopoulou et al., 2019). Finally, the integration of digital tools is crucial for cultivating a strategic mindset, enhancing financial literacy, creativity, and problem-solving skills (Soltanifar & Smailhodžić, 2021; Malach & Kysil, n.d.). This multi-faceted approach collectively equips individuals with the essential skills for success in the digital business landscape.

3.3.2 Increased Motivation & Engagement

Motivation and engagement are crucial for improving student learning outcomes, with strategies such as technology integration, gamification, and innovative teaching proving effective. Technology and elements like teamwork are shown to increase motivation and active participation (David & Weinstein, 2023). Fostering curiosity through exploration-based learning is also vital for sustaining interest (O'Keefe et al., 2017). These approaches encourage learners to take ownership of their learning, promoting autonomy and deeper involvement in classroom activities.**Game-based learning** significantly enhances motivation by incorporating elements such as points, badges, and leaderboards to create rewarding, engaging, and challenging experiences (Majdoub & Heilporn, 2024; Baah et al., 2024). This approach makes learning less intimidating, helps reduce cognitive load, and promotes satisfaction. While a sense of satisfaction can stimulate curiosity, it does not always equate to true learning and may stem from misconceptions (Liquin & Lombrozo, 2021). Therefore, the design of motivational strategies must balance enjoyment with cognitive challenge to ensure sustained engagement and meaningful learning. These strategies collectively aim to create educational environments that are both effective and enjoyable.

3.3.3 Practical Knowledge Application

Developing essential digital skills is crucial for enhancing employability and competitiveness in the modern labor market. AI competencies are vital for human–machine collaboration and require a technical and ethical understanding of AI (Sengsri & Khunratchasana, 2024). Foundational digital literacy and ICT integration are essential for productivity, necessitating continuous updates to keep pace with technological advancements (Coward, 2018; Hecker & Loprest, 2019; Laar, 2019). These competencies ensure that individuals remain adaptable and capable of leveraging emerging technologies effectively. As AI and automation reshape the workforce, there is a rising demand for analytical and interpersonal skills, which can be addressed through retraining (Mula & Ristiani, 2025). Moreover, AI and gamification** enhance data analysis and decision-making through adaptive learning and real-time skill assessments (Pandit et al., 2024; Liu & Cao, 2024). Such tools provide learners with opportunities to apply knowledge in dynamic contexts, strengthening their confidence in complex problem-solving. Training is crucial for bridging digital skill gaps and ensuring long-term employability (Orozova et al., 2024).

3.3.4 Behavioral & Attitude Change

The integration of AI and gamification enhances analytical thinking, decision-making, and problem-solving skills. AI provides advanced data processing for more informed business decisions (Pachar et al., 2024; Prasanth et al., 2023), while AI-driven gamification boosts critical thinking through personalized, adaptive learning (Costa et al., 2024; Li et al., 2024). This dual influence encourages learners to reflect on their choices, evaluate alternatives, and adjust strategies accordingly. This combination leverages technologies such as machine learning to create interactive environments, including simulations, that enhance experiential learning and strategic decision-making (Fuchsberger, 2016; Divya, 2024). Ultimately, these integrated approaches foster positive behavioral change and enhance cognitive skills across both business and educational contexts. As learners internalize these changes, they become more confident, autonomous decision-makers capable of navigating complex digital environments.

Stage 2. Evaluation of the AIDGAIDGVW-DEC Framework

The second stage of the study focused on evaluating the appropriateness and robustness of the AIDGAIDGVW-DEC

framework. To ensure both theoretical soundness and practical applicability, the framework underwent expert validation conducted by a panel of specialists in educational technology, digital entrepreneurship, and learning sciences. These experts were selected based on their academic and professional experience of at least 10 years in fields related to digital learning, curriculum design, and entrepreneurship development. This validation process ensured that the framework reflected not only theoretical principles but also practical considerations relevant to contemporary learning environments. During the validation process, each expert independently reviewed the conceptual framework, rated the clarity and suitability of its components, and provided optional written comments to support quantitative judgments. The evaluation examined five key dimensions: (1) appropriateness of input components, (2) suitability of the learning process, (3) adequacy of output assessment, (4) feasibility of implementation, and (5) theoretical alignment.

Experts rated each dimension using a 5-point Likert scale, where higher scores indicated stronger agreement with the framework's clarity, relevance, and applicability. The collected data were analyzed through mean scores ($\overline{x}$) and standard deviations to determine the level of suitability across each dimension. Interpretation of the results followed established benchmarks, ranging from "Absolutely Appropriate" (4.50–5.00) to "Absolutely Inappropriate" (1.00–1.49). This systematic approach ensured that the evaluation captured both consistency and consensus across expert judgments.

This stage of evaluation not only provided empirical evidence of the framework's validity but also highlighted areas for refinement and potential improvement, thereby strengthening its reliability as a foundation for instructional design and curriculum innovation in digital entrepreneurship education. The expert feedback reinforced the framework's potential to guide the development of immersive, AI-driven, and gamified instructional models tailored to 21st-century learning needs. The findings do not indicate final maturity of the framework but rather confirm its conceptual soundness and readiness for future empirical testing.

Table 3. The Appropriateness of the Conceptual Framework Structure

Evaluation Lists	Level of suitability	Level of assessment	
		$\bar{x}$	S.D.
1. Input Components Appropriateness	Absolutely Appropriate	4.65	0.58
2. Learning Process Appropriateness	Absolutely Appropriate	4.69	0.68
3. Output Assessment Appropriateness	Absolutely Appropriate	4.60	0.65
4. Implementation Feasibility	Absolutely Appropriate	4.71	0.55
5. Theoretical Alignment	Absolutely Appropriate	4.90	0.45
Overall	Absolutely Appropriate	4.71	0.47

The results presented in Table 3 reflect the expert evaluation of the AIDGAIDGVW-DEC conceptual framework. All dimensions were rated at the "Absolutely Appropriate" level, with mean scores ranging from 4.60 to 4.90. The highest mean score was obtained for Theoretical Alignment ($\bar{x} = 4.90$,S.D. $= 0.45$), indicating that experts considered the integration of artificial intelligence, gamification, and virtual world learning to be strongly consistent with contemporary theoretical perspectives. Implementation Feasibility ($\bar{x} = 4.71$,S.D. $= 0.55$) and Learning Process Appropriateness ($\bar{x} = 4.69$,S.D. $= 0.68$) were also rated very highly, suggesting that the framework can be realistically applied to instructional design and provides a coherent sequence of learning activities.

Although Output Assessment Appropriateness received the lowest mean score among the five dimensions, it was still evaluated as "Absolutely Appropriate" ($\bar{x} = 4.60$,S.D. $= 0.65$), implying that the proposed indicators for evaluating knowledge, behaviour, attitudes, and motivation are generally sound but may benefit from further refinement. Overall, the expert review of the framework's principles, concepts, and objectives indicates a very high level of appropriateness ($\bar{x}_{\text{overall}} = 4.71$,S.D. $= 0.47$), providing preliminary evidence of its content validity and practical relevance for instructional design in digital entrepreneurship education.

Table 4. Appropriateness of Input Components

Evaluation Lists	Level of suitability	Level of assessment	
		$\bar{x}$	S.D.
1. Digital Entrepreneurship Content covers the essential knowledge and skills required for becoming a digital entrepreneur.	Appropriate	4.50	0.53
2. Integration of Gamification Elements is appropriate for enhancing learner motivation and engagement.	Absolutely Appropriate	4.75	0.46
3. Utilization of Virtual World Technology is suitable for providing realistic and interactive learning experiences.	Absolutely Appropriate	4.63	0.52
4. Application of AI-Powered Personalization is appropriate for analyzing learner behavior and supporting adaptive and flexible learning pathways.	Absolutely Appropriate	4.75	0.46
5. Overall, the four components of the framework are appropriate, comprehensive, and can effectively support the development of digital entrepreneurial competencies.	Absolutely Appropriate	4.63	0.52
Overall	Absolutely Appropriate	4.65	0.58

The results in Table 4 show that all four input components of the AIDGAIDGVW-DEC framework were evaluated at high levels of suitability. Overall, experts rated the input components as "Absolutely Appropriate" ($\bar{x}_{\text{overall}} = 4.65, \text{S.D.} = 0.58$), indicating strong agreement that the framework includes the essential elements needed to support digital entrepreneurship competency development.

The highest mean scores were recorded for the integration of gamification elements and the application of AI-powered personalization ($\bar{x} = 4.75, \text{S.D.} = 0.46$ for both items). This suggests that experts particularly valued the framework's emphasis on motivational game mechanics and adaptive learning pathways based on learner behaviour. Utilization of virtual world technology was also rated as "Absolutely Appropriate" ($\bar{x} = 4.63, \text{S.D.} = 0.52$), reflecting the perceived suitability of immersive, interactive environments for providing realistic learning experiences.

Although digital entrepreneurship content received a slightly lower mean score ($\bar{x} = 4.50, \text{S.D.} = 0.53$), it was still evaluated as "Appropriate," implying that the knowledge and skills included are generally adequate but could be further expanded or specified in future refinements of the framework. Taken together, these findings provide expert-judgement support for the appropriateness and completeness of the framework's input components.

Table 5. Appropriateness of the Learning Process

Evaluation Lists	Level of suitability	Level of assessment	
		$\bar{x}$	S.D.
1. VR Game-Based Learning is appropriate for fostering problem-solving, collaboration, and critical thinking skills.	Absolutely Appropriate	4.63	0.52
2. AI Behavior Analysis is appropriate for adapting content and activities to individual learners.	Absolutely Appropriate	4.75	0.46
3. Gamification Engagement is appropriate for enhancing learner motivation and enjoyment.	Absolutely Appropriate	4.88	0.35
4. Continuous Assessment is appropriate for promoting reflection and knowledge application in real-world contexts.	Absolutely Appropriate	4.75	0.46
5. The sequence of steps is coherent and systematically connected.	Appropriate	4.50	0.76
6. The Feedback Loop effectively supports continuous improvement of the learning process.	Absolutely Appropriate	4.63	0.52
Overall	Absolutely Appropriate	4.69	0.68

The results are presented in Table 5. The appropriateness of the learning process was evaluated by experts and found to be absolutely appropriate ($\bar{x}$ = 4.69, S.D. = 0.68) , suggesting strong agreement that the sequence of learning activities is suitable for developing digital entrepreneurship competencies.

Among the six items, Gamification Engagement received the highest mean score ($\bar{x} = 4.88$,S.D. $= 0.35$), highlighting experts' confidence that game-based elements can effectively enhance learner motivation and enjoyment. AI Behavior Analysis and Continuous Assessment were also rated as "Absolutely Appropriate" ($\bar{x} = 4.75$,S.D. $= 0.46$ for both), indicating that adaptive content delivery and ongoing assessment are seen as key strengths of the learning process. VR Game-Based Learning and the Feedback Loop each achieved "Absolutely Appropriate" ratings ($\bar{x} = 4.63$,S.D. $= 0.52$), reflecting support for immersive, interactive activities and continuous improvement of instruction.

The sequence of steps obtained a slightly lower mean score ($\bar{x} = 4.50$,S.D. $= 0.76$) and was rated as "Appropriate," suggesting that, while the overall flow is coherent and systematically connected, there may be room for further clarification or refinement of the transitions between stages. Overall, these findings provide strong expert-judgement support for the appropriateness and internal coherence of the framework's learning process.

Table 6. Appropriateness of Output Assessment

Evaluation Lists	Level of suitability	Level of assessment	
		$\bar{x}$	S.D.
1. Digital Entrepreneurship Competency is clearly defined and can be assessed in measurable terms.	Appropriate	4.38	0.52
2. Motivation & Engagement can be appropriately observed and evaluated.	Absolutely Appropriate	4.88	0.35
3. Practical Knowledge Application has clear criteria linked to essential digital-era skills.	Appropriate	4.50	0.76
4. Behavioral & Attitude Change is appropriate for assessing analytical and strategic decision-making skills.	Absolutely Appropriate	4.75	0.46
5. Indicators are specific and measurable.	Appropriate	4.50	0.76
6. Holistic assessment provides comprehensive and useful information.	Absolutely Appropriate	4.63	0.52
Overall	Absolutely Appropriate	4.60	0.65

The results are presented in Table 6. The appropriateness of output assessment was evaluated by experts and found to be absolutely appropriate ($\bar{x}$ = 4.60, S.D. = 0.65). This indicates strong agreement that the framework's assessment components can provide meaningful information about learners' development in digital entrepreneurship education.

The highest rating was given to Motivation & Engagement ($\bar{x} = 4.88$, S.D. $= 0.35$), suggesting that experts were particularly confident that learners' motivational states and engagement levels can be effectively observed and evaluated. Behavioral & Attitude Change was also rated as "Absolutely Appropriate" ($\bar{x} = 4.75$, S.D. $= 0.46$), reflecting the perceived relevance of assessing analytical and strategic decision-making skills as key entrepreneurial outcomes. Holistic assessment achieved an "Absolutely Appropriate" rating as well ($\bar{x} = 4.63$, S.D. $= 0.52$), indicating that the combined set of indicators is viewed as comprehensive and practically useful.

In contrast, Digital Entrepreneurship Competency, Practical Knowledge Application, and the specificity of indicators were rated as "Appropriate" rather than "Absolutely Appropriate" ($\bar{x} = 4.38$,S.D. $= 0.52$; $\bar{x} = 4.50$,S.D. $= 0.76$; and $\bar{x} = 4.50$,S.D. $= 0.76$, respectively). These slightly lower scores suggest that, although the constructs are generally clear and measurable, further refinement of the competency definitions, criteria for practical application, and indicator specificity could strengthen the robustness of the assessment system. Overall, the findings provide expert-judgement support for the appropriateness of the framework's output assessment, while also pointing to concrete directions for future improvement.

Table 7. Implementation Feasibility Assessment

Evaluation Lists	Level of suitability	Level of assessment	
		$\bar{x}$	S.D.
1. The framework can be realistically implemented in educational institutions.	Absolutely Appropriate	4.88	0.52
2. The use of VR and AI technology in the learning process is feasible in the context of educational settings.	Appropriate	4.50	0.35
3. Teachers or instructors can effectively utilize this framework in learning management	Absolutely Appropriate	4.88	0.76
4. The framework is flexible and can be adapted to different grade levels or target groups.	Absolutely Appropriate	4.75	0.46
5. Learners can realistically access the learning processes outlined in this framework, consistent with their technological readiness.	Appropriate	4.50	0.76
6. This framework facilitates ongoing monitoring and long-term development after actual implementation.	Absolutely Appropriate	4.75	0.52
Overall	Absolutely Appropriate	4.71	0.55

The results are presented in Table 7. Experts evaluated the implementation feasibility of the AIDGAIDGVW-DEC framework at the "Absolutely Appropriate" level, with an overall mean score of $\bar{x} = 4.71$ and S.D. = 0.55, indicating strong agreement that the framework can be realistically implemented in educational settings.

Table 8. Theoretical Alignment Assessment

Evaluation Lists	Level of suitability	Level of assessment	
		$\bar{x}$	S.D.
1. The framework aligns with the principles of 21st-century learning theories.	Absolutely Appropriate	5.00	0.00
2. The gamification concepts within this framework are appropriately aligned with Gamification Theory principles.	Absolutely Appropriate	5.00	0.00
3. The integration of VR and AI technologies in the framework is consistent with EdTech and Immersive Learning theories and concepts.	Absolutely Appropriate	4.75	0.46
4. References to research are appropriate and up-to-date.	Absolutely Appropriate	4.88	0.35
5. Overall, this framework is linked to appropriate theoretical principles that clearly explain the design of the learning process logically.	Absolutely Appropriate	4.88	0.35
Overall	Absolutely Appropriate	4.90	0.45

The results in Table 8 show that experts rated the theoretical alignment of the AIDGAIDGVW-DEC framework as "Absolutely Appropriate," with an overall mean score of $\bar{x} = 4.90$ (S.D. = 0.45). The highest ratings were given to the alignment with 21st-century learning theories and gamification theory ($\bar{x} = 5.00$,S.D. $= 0.00$ for both), while the integration of VR and AI with EdTech and immersive learning concepts, the currency of the research references, and the overall theoretical linkage of the framework also received "Absolutely Appropriate" evaluations ($\bar{x} = 4.75$–4.88). These results indicate strong expert agreement that the framework is firmly grounded in relevant contemporary theoretical principles.

Table 9. Expert Evaluation of the AIDGAIDGVW-DEC Framework (N = 5)

Dimension	Mean ($\bar{x}$)	SD	Interpretation
Conceptual Framework Structure	4.71	0.47	Absolutely Appropriate
Input Components	4.65	0.58	Absolutely Appropriate
Learning Process	4.69	0.68	Absolutely Appropriate
Output Assessment	4.60	0.65	Absolutely Appropriate
Implementation Feasibility	4.71	0.55	Absolutely Appropriate
Theoretical Alignment	4.90	0.45	Absolutely Appropriate

The results in Table 9 summarize the expert evaluation of the AIDGAIDGVW-DEC framework. All six dimensions achieved mean scores above 4.60 on a 5-point Likert scale, indicating a consistently high level of appropriateness across the framework's conceptual structure, input components, learning process, output assessment, implementation feasibility, and theoretical alignment. Theoretical Alignment received the highest mean score ($\bar{x} = 4.90$, S.D. $= 0.45$), suggesting that experts strongly agreed the framework is firmly grounded in contemporary theories of learning, gamification, and educational technology. Although Output Assessment had the lowest mean ($\bar{x} = 4.60$, S.D. $= 0.65$), it was still interpreted as "Absolutely Appropriate," implying that the proposed indicators for evaluating competencies, behaviour, attitudes, and motivation are robust and largely well-constructed. Overall, these findings indicate very strong expert support for the content validity, practicality, and theoretical soundness of the AIDGAIDGVW-DEC framework.

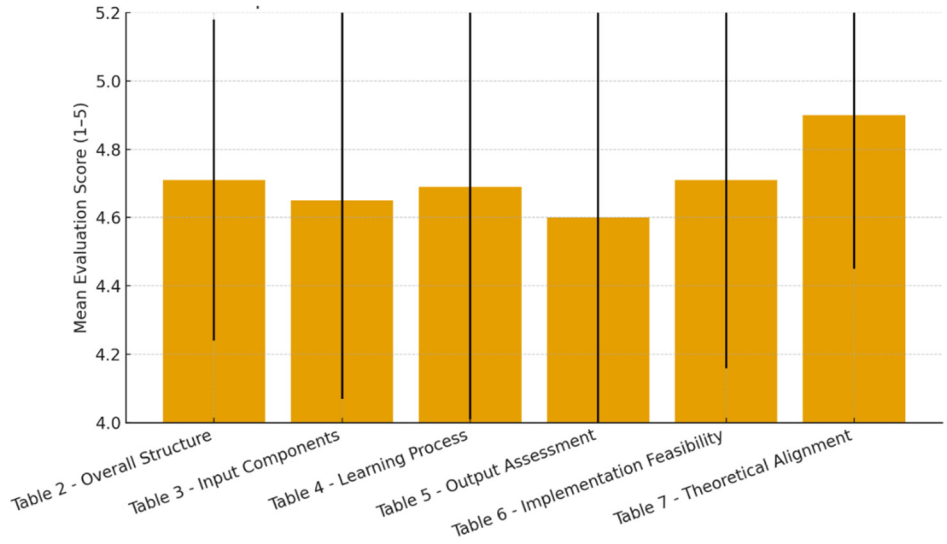

Figure 5. Expert Evaluation Results Across Framework Dimensions

Figure 5. Expert evaluation results across framework dimensions (Table 2 – 7). The bar chart presents the mean evaluation scores with standard deviations (error bars), demonstrating that all dimensions were rated at a high level of appropriateness ($\geqslant$ 4.50). This pattern indicates strong and consistent expert support for the framework's conceptual structure, input components, learning process, output assessment, implementation feasibility, and theoretical alignment.

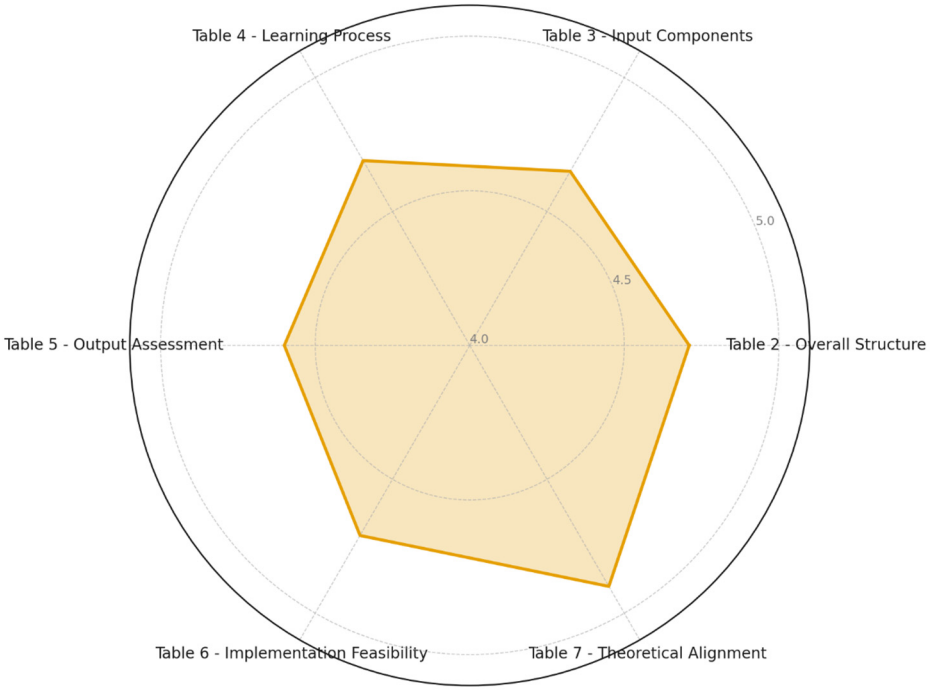

Figure 6. Radar Chart of Expert Evaluation (Table 2–7)

Figure 6. Radar chart of expert evaluation (Table 2–7). The radar visualization illustrates the balance across all dimensions, with Theoretical Alignment achieving the highest score (M = 4.90) and Output Assessment recording the lowest score (M = 4.60). All domains remain within the "Absolutely Appropriate" range. This pattern confirms that the framework is perceived as consistently strong across structural, pedagogical, assessment, implementation, and theoretical aspects.

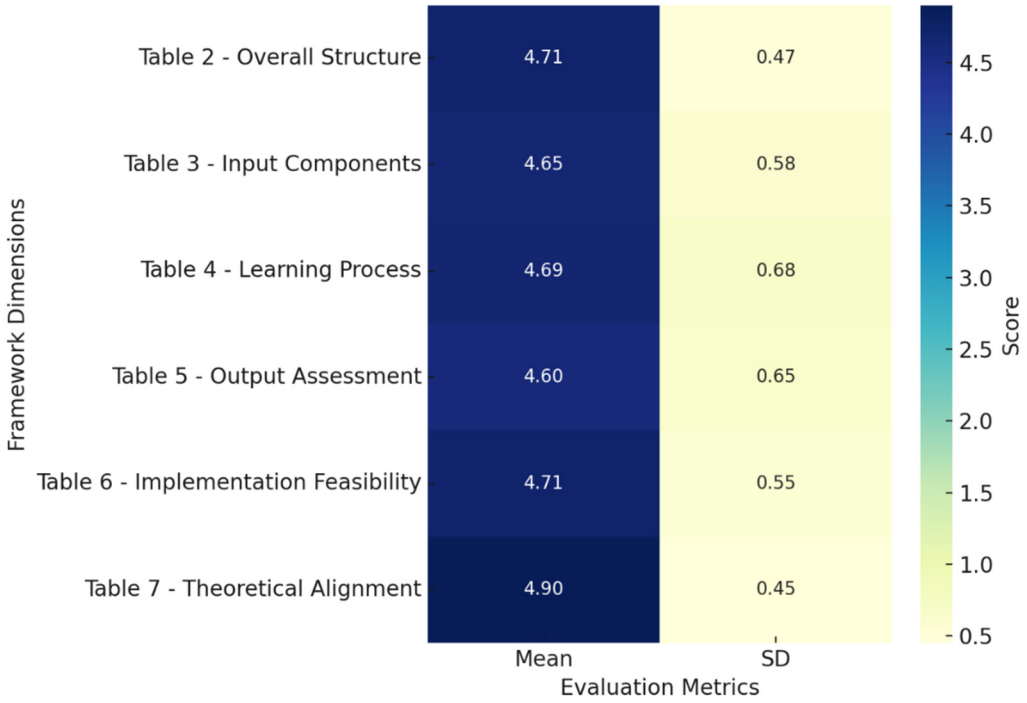

Figure 7. Heatmap of Expert Evaluation (Mean & SD) from Table 2–7

Figure 7. Heatmap of expert evaluation (Table 2–7). The heatmap highlights both mean scores and standard deviations, emphasizing the consistently high evaluations across all dimensions, with minimal variability in Theoretical Alignment (SD = 0.45) and comparatively higher variability in Output Assessment (SD = 0.65). This pattern suggests that experts were highly consistent in their judgments of the framework's theoretical grounding, while views on the output assessment indicators were slightly more diverse, though still within the "Absolutely Appropriate" range.

4. Discussion

As this study is conceptual and based on expert evaluation, the findings should be interpreted as indicators of theoretical appropriateness rather than learner-level outcomes. The findings of this study provide substantial support for the primary hypothesis that the AIDGAIDGVW-DEC framework represents a coherent and theoretically grounded approach for fostering digital entrepreneurship competencies within gamified virtual world learning environments. The expert validation results indicate strong agreement regarding the relevance and clarity of the framework's components, affirming its potential to guide the development of competencies such as opportunity recognition, decision-making, and self-regulation. This aligns with prior research emphasizing the value of immersive and adaptive learning experiences for cultivating entrepreneurial mindsets (Lampropoulos & Kinshuk, 2024; Xin & Xiaohong, 2023). The high suitability ratings across all dimensions further support theoretical claims that gamified and personalized virtual environments can enhance learner engagement and sustained participation (Grivokostopoulou et al., 2019; Isabelle, 2020).

The secondary hypothesis concerning the role of AI-driven feedback mechanisms was also supported through expert judgment. Reviewers noted that adaptive guidance embedded within virtual simulations is likely to enhance learner performance; however, they also highlighted that individual differences in digital readiness may influence the effectiveness of such mechanisms. This observation extends existing scholarship by underscoring the importance of aligning adaptive support not only with performance data but also with learner characteristics and contextual factors (Isabelle, 2020; Lampropoulos & Kinshuk, 2024).

Several considerations may shape the interpretation of the framework's evaluated appropriateness. First, potential bias may arise from the expert panel's professional backgrounds, which could influence their perspectives on the integration of AI and gamification. Second, while the evaluation confirmed the conceptual robustness of the framework, it did not include classroom-based or learner-level data, which may limit insights into actual learner behaviour and outcomes. Third, the indicators used to assess digital entrepreneurship competencies, though grounded in validated literature, may not fully capture complex constructs such as creativity, resilience, or collaborative innovation. Nevertheless, the high consistency of ratings across all expert reviewers suggests strong theoretical and practical relevance.

The mechanisms by which the framework is expected to facilitate competency development reflect the interplay of experiential learning, immediate AI-supported feedback, and goal-oriented gamification. Together, these components are anticipated to support iterative decision-making, reflection, and situated learning—principles well documented in constructivist and simulation-based pedagogies (Grivokostopoulou et al., 2019). Although this study demonstrated high implementation feasibility at the conceptual level, future research should examine how the framework functions across different cultural, institutional, and technological contexts to determine its scalability.

Overall, this study demonstrates that the AIDGAIDGVW-DEC framework provides a theoretically grounded and practically viable foundation for designing learning environments that cultivate digital entrepreneurship competencies. By integrating immersive virtual experiences with adaptive AI support and gamified structures, the framework contributes to emerging discussions on competency-based, technology-enhanced education. Future research should empirically test the framework through classroom implementation, longitudinal studies, and design-based research to evaluate its effectiveness, refine its components, and examine its generalizability across diverse educational settings.

5. Conclusion

The AIDGAIDGVW-DEC framework advances the field of digital entrepreneurship education by providing a robust, theory-driven, and empirically validated model that integrates artificial intelligence, gamification, and immersive virtual world technologies. The results of the expert evaluation confirm the framework's high level of appropriateness across all key dimensions, including input components, learning processes, output assessments,

implementation feasibility, and theoretical alignment. With mean scores ranging from 4.60 to 4.90, the framework demonstrates both conceptual soundness and practical feasibility, underscoring its potential as a replicable model for designing innovative learning environments.

From a theoretical standpoint, the framework enriches scholarship by synthesizing gamification theory, immersive learning principles, and AI-driven personalization into a cohesive structure. It contributes to the growing body of literature that emphasizes experiential, adaptive, and technology-enhanced approaches as catalysts for cultivating entrepreneurial mindsets and competencies in the 21st century.

Practically, the framework offers educators a scalable and flexible tool for fostering motivation, engagement, decision-making, and entrepreneurial confidence among learners. Its validation by experts highlights not only its clarity and relevance but also its applicability across diverse educational settings.

Future research should extend this work by empirically testing the framework across longitudinal and cross-cultural contexts, as well as exploring refinements to its personalization algorithms and assessment strategies. Such efforts will strengthen its generalizability and ensure its continued relevance in rapidly evolving digital economies.

In sum, the AIDGAIDGVW-DEC framework represents both a conceptual innovation and a practical pathway for preparing learners to thrive as digital entrepreneurs. By bridging theory and practice, it provides a foundation for reimagining entrepreneurship education in alignment with the opportunities and challenges of the digital era.

While conceptually robust, the AIDGAIDGVW-DEC framework now requires empirical validation through classroom-based implementation, longitudinal study, or design-based research. Such work will be essential to refine the framework's components and confirm its effectiveness across varied educational contexts.

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Authors contributions

Narudon Rudto was responsible for the conceptualization and overall research administration. Assistant Professor Dr. Thada Jantakoon supervised the validation, review, and revision of the manuscript. Assistant Professor Rukthin Laoha reviewed the manuscript. All authors have read and approved the final version of the manuscript.

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No additional data are available.