

A Digital Learning Ecosystem through Metaverse Experiences to Develop Modern Digital Entrepreneurs Competencies

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Abstract

This study explores the development and evaluation of a digital learning ecosystem through metaverse experiences aimed at enhancing the competencies of modern digital entrepreneurs. The objectives were as follows: (1) to study the digital learning ecosystem through metaverse experiences, (2) to design and develop a digital learning ecosystem using a metaverse experience, and (3) to study the results of using the digital learning ecosystem through metaverse experiences. The research method was divided into three phases based on these objectives. The first phase involved studying the digital learning ecosystem through metaverse experiences. In the second phase, the digital learning ecosystem for design and development was evaluated for its effectiveness by twelve experts using a suitability assessment form. The third phase examined the outcomes of using the digital learning ecosystem through metaverse experiences, focusing on digital entrepreneurs' competencies and innovative thinking skills. The study included 30 participants from higher education institutions in Thailand. The findings revealed a significant improvement in learners' digital competencies post-intervention with a large effect size (Cohen's $d = 1.72$), indicating the substantial impact of the digital learning ecosystem through metaverse experiences. Additionally, there was a notable enhancement in innovative thinking skills as evidenced by high mean scores in creativity, problem-solving, value creation, presentation, and implementation. The experts found the digital learning ecosystem through metaverse experiences to be highly appropriate and effective.

Keywords: digital learning ecosystem, metaverse, experienced learning, digital competencies, modern entrepreneurial graduates

1. Introduction

The 17 Sustainable Development Goals (SDGs) aim to ensure a better world by 2030. Goal 4 specifically focuses on ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. According to Thailand's strategic development plan, the government prioritizes human development through education and the industrial revolution with digital technology. Additionally, the promotion of start-ups and SMEs is considered a critical mechanism for driving the country's economic development. To this end, the government has implemented various laws and policies to enhance the potential of start-ups and SMEs, enabling them to compete and grow into successful enterprises. This includes the enactment of the Small and Medium Enterprises Promotion Act and the establishment of the National Start-up Committee, which aligns with the strategic development plan of the Faculty of Business Administration and Information Technology. The vision of the Faculty is to become a leader in producing professional practitioners in business administration and information technology at both the national and ASEAN levels. This vision supports the policy-driven transition from a traditional economy to an innovation-driven economy under the Thailand 4.0 initiative. The role of higher education institutions is to organize teaching and learning activities that equip learners with academic and professional knowledge in their respective fields, ensuring they possess the attributes specified by their curriculum. The process of producing graduates involves various factors, aligning with the first mission of teaching and producing graduates. The Digital Learning Ecosystem The use of digital learning ecosystems has a significant influence on learners' engagement. Research results show that the functionality of digital environments plays a key role in shaping learner's engagement during lectures. Features like showing teachers' slideshows on their own devices increase emotional engagement and lead to better academic results (Taha & Abdulrahman, 2023).

Additionally, the use of information and communication technology (ICT) in e-learning has been found to have a strong statistical effect on learners' academic success, highlighting the positive relationship between ICT use and academic success in higher education (Hutain & Michinov, 2022). Maintaining appropriate alignment between learners' digital practices and formal learning methods is crucial in preventing friction and ensuring optimal academic performance. This emphasizes the need for a balanced integration of digital media in education. By effectively using technology in line with educational goals, educators can increase learners engagement and ultimately improve educational outcomes (Hietajärvi et al., 2022). Experienced Learning has many advantages over traditional learning methods, emphasizing the role of experience in knowledge acquisition and skill development. Research highlights that experiential learning increases self-confidence, promotes a deeper understanding of the complex relationships among subjects, provides ongoing feedback for evaluating progress, and fosters a continuous cycle of learning and knowledge acquisition. Studies have shown that experiential learning methods, such as interactive task-based sessions, significantly improve communication skills in business administration learners compared to traditional lecture-based approaches. Additionally, combining teachers' experience with the knowledge transfer process through methods such as experiential knowledge distillation has been shown to outperform standard knowledge distillation techniques, leading to state-of-the-art results in tasks such as image classification. These findings together highlight the effectiveness of experiential learning in improving learning outcomes and skill development in various domains is an engaging learning process in which learners actively participate and reflect on their experiences. This type of learning is not limited to hands-on laboratory experiments, internships, field training, or practical training. It is well-planned, supervised, and evaluated, encompassing knowledge, activities, and reflection. Experienced Learning promotes interdisciplinary learning, digital citizenship, career development, and involves learners intellectually, creatively, emotionally, socially, or physically. The Metaverse consists of many technologies that have the potential to revolutionize the world of the technology industry in the next 5-10 years. There are 8 elements of the Metaverse related to Industry 4.0: 1. Digital Currency or digital money 2. Online Shopping or buying and selling goods and services online 3. Workplace Automation or automation systems in the workplace 4. Social Media or online social networks 5. Digital Humans or realistic digital representations of humans and experiential learning 6. Natural Language Processing or natural language processing technology 7. Infrastructure or the foundational systems and structures 8. Device Independence or systems that can operate and interact without dependence on specific languages or traditional operating systems (Gartner, 2022). Kasikorn Research Center (KResearch, 2021) stated that people's interaction and familiarity with digital technology have increased during the COVID crisis. Additionally, advertising revenue from global platform providers tends to slow down due to the increasing number of online platforms. Therefore, this is likely the main reason pushing global platform providers to take the initiative to develop the Metaverse. This represents an important future opportunity that both small and large businesses must keep an eye on. The Metaverse will help create new and different experiences for users compared to the past, such as traveling through the virtual world, viewing and testing products in the virtual world, and buying and selling in-game assets (brand inside, 2021). The Metaverse became even more popular when Mark Zuckerberg announced that Facebook would continue to develop the company into a Metaverse Company in the next five years, making brands around the world interested in applying technology to their businesses to stand out. And there are many leaders of the future, including Facebook, Samsung, Mercedes and Shopify. The Metaverse is a collective virtual shared space, created by the convergence of virtually enhanced physical reality and physically persistent virtual space, including the sum of all virtual worlds, augmented reality, and the internet. It is a virtual universe that encompasses multiple interconnected digital environments where users can interact, socialize, play, and work through their digital avatars. The Metaverse is seen as the next evolution of the internet, providing immersive and interactive experiences that blend the physical and digital worlds. The Metaverse plays an important role in experiential learning by offering an immersive and interactive environment that increases learners engagement, motivation, and active participation in the learning process (AbuKhoua, 2023). Using Virtual Reality (VR) and Augmented Reality (AR), the Metaverse provides a personalized and adaptive experience that stimulates intrinsic motivation among learners, ultimately improving academic performance (Morsanuto et al., 2023). By creating virtual spaces that mirror real-world environments, the Metaverse allows learners to engage in simulations and hands-on experiences that may not be accessible in traditional environments. This promotes memory formation and enhances learning outcomes. Furthermore, the Metaverse presents unique opportunities to manipulate different aspects of the learning experience, such as emotions, motivation, interests, and previous experiences, making learning more engaging and effective (Muthmainnah et al., 2023). Digital competencies for modern entrepreneurial graduates encompass a range of skills and knowledge areas essential for effectively navigating and leveraging digital technologies in entrepreneurial contexts. These competencies include digital literacy, understanding and effectively using digital tools, platforms, and applications relevant to entrepreneurship; information management,

the ability to efficiently search, evaluate, and manage digital information, including data analysis and interpretation; communication and collaboration, proficiency in using digital communication tools to interact, collaborate, and network with stakeholders, customers, and team members; content creation, skills in creating digital content, such as websites, social media posts, videos, and other multimedia materials, to promote and manage a business; cybersecurity awareness, understanding of cybersecurity principles and practices to protect digital assets, data, and online presence; digital marketing, knowledge of digital marketing strategies, including social media marketing, SEO, email marketing, and online advertising; e-commerce, ability to set up, manage, and optimize online sales channels, including understanding e-commerce platforms and payment systems; data-driven decision making, competence in using data analytics and business intelligence tools to make informed business decisions; innovation and technology integration, ability to integrate new technologies and innovative solutions into business practices to enhance productivity and competitiveness; agility and adaptability, skills to quickly adapt to new digital trends, technologies, and market changes, and the ability to learn continuously; problem-solving, proficiency in using digital tools and resources to solve business problems and streamline operations; ethical and responsible use, understanding the ethical implications of digital technology use and promoting responsible behavior online. These digital competencies are critical for modern entrepreneurial graduates as they equip them with the necessary tools to effectively start, manage, and grow businesses in a digitalized world. Rapidly changing technology affects teaching to encourage learners to become entrepreneurial graduates, making it difficult to design courses that are modern and meet market needs. There is a lack of actual experience among teachers, and opportunities for learners to learn through real business experience are still limited. The connection between universities and businesses to create networks and business opportunities is insufficient. There is a lack of resources and financial support for learners who want to start a business. Communication, negotiation, and problem-solving skills are inadequately developed. Teaching about the use of technology in business is not up-to-date and not comprehensive enough. There is also a lack of teaching innovations to promote the entrepreneurial qualities of graduates. Technology challenges the development of entrepreneurial graduates. Modern curriculum design that provides real-world experiences is important. Innovative teaching approaches are needed to further enhance the quality of entrepreneurial graduates. For this reason, the researcher is interested in doing research to develop the competency of modern digital entrepreneurs to create a learning process in conjunction with modern technology. To promote modern entrepreneurial learners in higher education institutions.

2. Research Objects

This study has research questions, research objectives and research hypotheses as follows:

2.1 Research Question

- 1) What are the components of the metaverse experiential digital learning ecosystem?
- 2) How does the metaverse experiential digital learning ecosystem enhance modern digital entrepreneurs' competencies?
- 3) How does after using the digital learning ecosystem through the metaverse experience?

2.2 Research Objectives

- 1) To study the digital learning ecosystem through metaverse experiences.
- 2) To design and develop a digital learning ecosystem through a metaverse experience.
- 3) To study the results of using the digital learning ecosystem through metaverse experiences about

To compare modern digital entrepreneurs' competencies before and after using the digital learning ecosystem through metaverse experiences

To compare assessment 1) Creativity 2) Problem solving 3) Value creation 4) Presentation 5) Implementation affect entrepreneur innovation skills.

2.3 Research Hypothesis

- 1) Learners have higher modern digital entrepreneurs' competencies after studying with the digital learning ecosystem through metaverse experiences compared to before studying.
- 2) The mean scores of the 5 assessment groups no differ significantly.

3. Literature Review

3.1 Digital Learning Ecosystem (DLE)

A digital learning ecosystem is a comprehensive framework that integrates various components to facilitate and

enhance learning experiences through digital means. It encompasses individuals, content, technology, culture, and strategies, both within and outside educational institutions, impacting formal and informal learning (Sergey et al., 2023). Key elements of a digital learning ecosystem include individuals such as learners, educators, administrators, and other stakeholders involved in the learning process; content, which consists of digital educational materials such as e-books, online courses, multimedia resources, and interactive tools; technology, which includes digital tools and platforms that support learning, including learning management systems, virtual classrooms, and mobile learning apps; culture, which refers to the attitudes, values, and practices that promote and support digital learning within an institution or community; and strategies, which are the methods and approaches used to deliver and assess learning, including blended learning, gamification, and personalized learning plans (Pedro et al., 2022). In a digital learning ecosystem, knowledge is continuously transformed and created using the internet, with various activities and interactions taking place. This system supports a dynamic and adaptable learning environment, enabling learners to access resources and engage in learning experiences beyond traditional classroom boundaries (Christina et al., 2022).

3.2 Metaverse for Business

The Metaverse presents a changing landscape for businesses in various sectors, particularly in marketing activities. As the Metaverse evolves from the idea stage to the business model stage, understanding the processes of value proposition creation, delivery, and acquisition becomes critical for successful operations (Egi, et al., 2023). The Metaverse for business refers to the use of virtual and augmented reality environments to create immersive and interactive experiences that can transform various aspects of business operations and customer engagement. It leverages advanced technologies to provide new opportunities for businesses to innovate, collaborate, and connect with customers in ways that were previously not possible (Ilaria et al., 2023). Key aspects of the metaverse for business include virtual workspaces, creating virtual offices and meeting rooms where employees can collaborate and interact in a 3D environment, enhancing remote work and global collaboration; customer engagement, offering immersive customer experiences such as virtual showrooms, product demonstrations, and interactive marketing campaigns to engage customers in more meaningful ways; e-commerce, developing virtual stores where customers can browse, try on, and purchase products in a realistic 3D setting, enhancing the online shopping experience; training and development, utilizing virtual environments for employee training and professional development, providing hands-on learning experiences that are more engaging and effective; event hosting, organizing virtual conferences, trade shows, and events that can attract a global audience, reduce costs, and offer unique interactive experiences; product design and prototyping, using virtual reality to design, test, and visualize products before they are manufactured, improving the efficiency and effectiveness of the product development process; brand building, creating branded virtual environments that reflect the company's identity and values, allowing for innovative marketing and brand storytelling; data visualization, leveraging immersive 3D environments to analyze and present complex data in more intuitive and actionable ways. The Metaverse for business represents a significant shift in how companies operate, engage with customers, and create value. By adopting metaverse technologies, businesses can stay competitive, drive innovation, and open new revenue streams in a rapidly evolving digital landscape. The study highlights the challenges and opportunities of using the business model canvas for digital businesses in the Metaverse, emphasizing the importance of immersive customer experiences. The Metaverse enables users to create and manage their virtual stores, supporting various business functions and interactions within the virtual environment. However, maintaining user engagement and creating immersive customer experiences in virtual worlds pose challenges for businesses operating in the Metaverse, requiring continuous monitoring and adaptation (Meepung & Kannikar, 2022).

3.3 Learning Experience Design (LXD)

Learning Experience Design (LXD) is a progressive approach in educational technology and learning design that focuses on increasing learner engagement and performance (Boonrat Plangsorn, 2023). LXD plays an important role in the creation of curricula and training materials that cater to diverse learner populations. The metaverse is seen as a promising area to enhance LXD by offering adaptive and immersive learning experiences based on aspects such as previous experiences, emotions, motivation, and interest (AbuKhoua, 2023). Companies often design learners experiences with performance in mind, but the shift towards a more human-focused approach and the integration of digital technologies are reshaping interactions with learners and the success of e-learning projects (Olivia, K., Richards., 2023).

3.4 Experienced Learning (EL)

Experiential learning is important for skill development because it provides practical training, promotes collaborative skills, and increases problem-solving abilities, ensuring the acquisition of industry-relevant skills

through models such as project-based learning (Amna et al., 2022). This approach helps learners develop the collaborative skills required for the 21st-century workplace. Additionally, experiential learning allows individuals to gain practical experience, clarify values, and use previous learning experiences to develop a deeper understanding and discover new knowledge (Muhammad Hasan et al., 2023). This method not only equips learners with industry-ready skills but also enhances the creative, analytical, and digital skills needed for future employment. Overall, experiential learning bridges the gap between theoretical knowledge and practical application, ensuring that learners are well-prepared to take on real-world challenges and excel in their chosen fields (Devika et al., 2022).

3.5 Characteristics of Modern Entrepreneurs

Modern entrepreneurial display the characteristics necessary for success in today's dynamic business environment. They possess entrepreneurial competence, a key component of professional competence that guides their activities and leads them to entrepreneurial success (Raxmatullaeva et al., 2023). These graduates exhibit positive qualities such as being adventurous, goal-oriented, creative, and proactive, while avoiding negative traits such as arrogance and limitations in their approach to work. They also demonstrate a sense of entrepreneurship and initiative, which are important competencies in the modern educational environment, as highlighted by European efforts to develop entrepreneurial abilities in learners (Khairi et al., 2021). Additionally, the ability to navigate and build a strong business network is a crucial characteristic, providing them with the support and resources needed for their ventures. Overall, modern entrepreneurial graduates are innovative, courageous, and adept at leveraging their skills and networks to succeed in the competitive business landscape. Modern entrepreneurial graduates possess innovative thinking, the ability to develop creative solutions, and the capacity to identify new opportunities (Raxmatullaeva et al., 2023). They are willing to take calculated risks and embrace uncertainty. Resilient, they recover from setbacks and persist in facing challenges. Adaptable, they quickly adjust to changing circumstances and technologies. Strong leadership skills enable them to inspire and guide teams. Critical thinking skills help them analyze situations and makes informed decisions. They are proficient in digital tools, adept at building networks, and understand financial principles.

3.6 Digital Competencies for Modern Entrepreneurs

In the current digital age, modern entrepreneurial require a set of digital competencies to succeed in the evolving business landscape. These competencies include digital marketing strategy, social media marketing, search engine optimization, content marketing, and email marketing (Raxmatullaeva et al., 2023). Digitalization underscores the importance of developing entrepreneurial competencies as a mechanism for preparing learners for careers and ensuring success in entrepreneurial activities (Olga et al., 2021). Furthermore, the impact of the digital economy on fields such as engineering and technology highlights the need for graduates to acquire digital competencies in higher education to meet the demands of the digital economy and address conflicts in skill development. Overall, integrating digital communication skills into entrepreneurial education programs is essential for promoting innovation, customer engagement, and successful product development in the digital age (Papageorgiou et al., 2021). Digital competencies for modern entrepreneurial graduates encompass a range of skills and knowledge areas essential for effectively navigating and leveraging digital technologies in entrepreneurial contexts. These competencies include digital literacy, which involves understanding and effectively using digital tools, platforms (Raxmatullaeva et al., 2023), and applications relevant to entrepreneurship; information management, which is the ability to efficiently search, evaluate, and manage digital information, including data analysis and interpretation; communication and collaboration, which refers to proficiency in using digital communication tools to interact, collaborate, and network with stakeholders, customers, and team members; content creation, which involves skills in creating digital content such as websites, social media posts, videos, and other multimedia materials to promote and manage a business; cybersecurity awareness, (Ahmad et al., 2023) which is the understanding of cybersecurity principles and practices to protect digital assets, data, and online presence; digital marketing, which includes knowledge of digital marketing strategies such as social media marketing, SEO, email marketing, and online advertising; e-commerce, which is the ability to set up, manage, and optimize online sales channels, including understanding e-commerce platforms and payment systems; data-driven decision making, which is the competence in using data analytics and business intelligence tools to make informed business decisions; innovation and technology integration, which involves the ability to integrate new technologies and innovative solutions into business practices to enhance productivity and competitiveness; agility and adaptability, which are skills to quickly adapt to new digital trends, technologies, and market changes, and the ability to learn continuously; problem-solving, which is proficiency in using digital tools and resources to solve business problems and streamline operations; and ethical and responsible use, which is understanding the ethical implications of digital technology use and promoting responsible behavior online. These digital competencies are critical for modern entrepreneurial

graduates as they equip them with the necessary tools to effectively start, manage, and grow businesses in a digitalized world (Erni et al., 2023).

3.7 Digital Competencies with the Metaverse for Modern Entrepreneurs

In the current landscape of digital transformation and the emergence of the metaverse, modern entrepreneurial graduates require a strong set of digital competencies to succeed in the evolving business environment. Digitization and virtual simulation, as highlighted in (Raxmatullaeva et al., 2023), emphasize the need for entrepreneurs to have digital communication skills, including digital marketing strategies and social media engagement. Furthermore, graduates' entrepreneurial abilities, focused on activities directed towards entrepreneurial success, are crucial in preparing learners for careers (Servetnik et al., 2022). The Metaverse, according to (Papageorgiou et al., 2021), offers numerous entrepreneurial opportunities in sectors such as digital marketing, education, and tourism, highlighting the importance of digital competencies for entrepreneurs aiming to capitalize on this transformative space. Integrating these digital skills into entrepreneurial education programs is essential to equip graduates with the tools they need to thrive in the digital age. Digital competencies with the Metaverse for modern entrepreneurial graduates encompass a range of skills and knowledge areas essential for effectively navigating and leveraging digital technologies in entrepreneurial contexts. These competencies include digital literacy, understanding and effectively using digital tools, platforms, and applications relevant to entrepreneurship within the metaverse; virtual collaboration, proficiency in using virtual communication tools to interact, collaborate, and network with stakeholders, customers, and team members within immersive environments; content creation, skills in creating digital content such as virtual storefronts (Davide et al., 2023), interactive experiences, and multimedia materials to promote and manage a business in the metaverse; cybersecurity awareness, understanding of cybersecurity principles and practices to protect digital assets, data, and online presence in virtual environments; digital marketing, knowledge of digital marketing strategies, including social media marketing, SEO, email marketing, and online advertising, adapted for virtual and augmented reality platforms; e-commerce, ability to set up, manage, and optimize online sales channels within the Metaverse, including understanding virtual marketplaces and payment systems; innovation and technology integration, ability to integrate new technologies and innovative solutions into business practices within the Metaverse to enhance productivity and competitiveness (Cristinel, Constantin, 2023); agility and adaptability, skills to quickly adapt to new digital trends, technologies, and market changes within the Metaverse, and the ability to learn continuously; problem-solving, proficiency in using digital tools and resources to solve business problems and streamline operations in a virtual environment; ethical and responsible use, understanding the ethical implications of digital technology use and promoting responsible behavior online, especially within immersive and interactive spaces; virtual customer engagement, creating immersive customer experiences, such as virtual showrooms and interactive marketing campaigns, to engage customers in more meaningful ways. These digital competencies are critical for modern entrepreneurial graduates as they equip them with the necessary tools to effectively start, manage, and grow businesses in a digitalized and virtualized world (Raxmatullaeva et al., 2023).

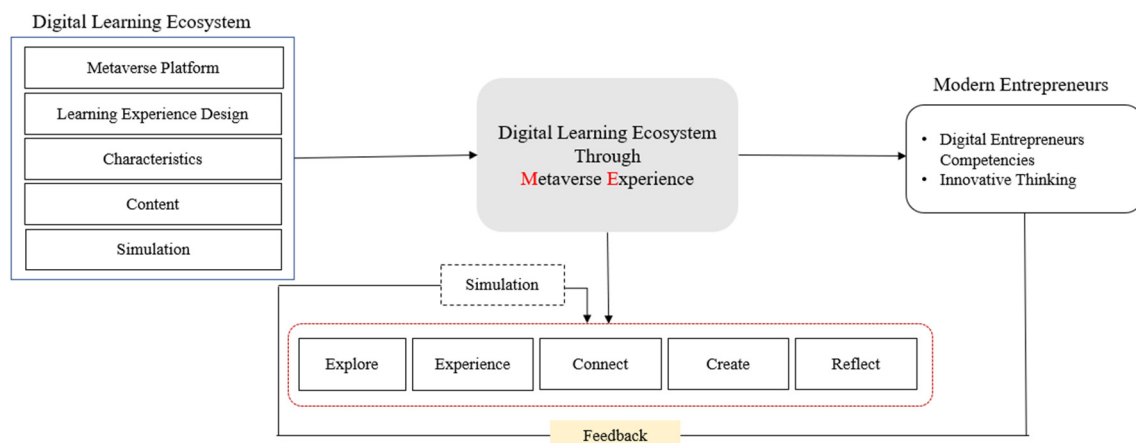


Figure 1. Research conceptual framework

Figure 1, show conceptual framework of research input factors in the digital learning ecosystem: metaverse platform for creating learning experiences, design of learning experiences in the metaverse, characteristics of modern digital entrepreneurs' competencies in the metaverse, content used in learning, simulation of situations for practice and learning. Steps in the digital learning ecosystem through metaverse experience: explore, experience, connect, create, reflect—Outcome modern digital entrepreneurs' competencies, innovative thinking skills and feedback.

4. Methodology

This research is research and development with a digital learning ecosystem through metaverse experiences to develop the capabilities of modern digital entrepreneurs. It was a single group pretest and posttest design. Using a test to measure knowledge before studying with the Metaverse experiential digital learning ecosystem, the experimental model will collect data from pre- and post-tests. The experiment was conducted through a digital learning ecosystem through the Metaverse experience installed using Spatial.io that the researchers developed. An important part is the entrepreneurial development lab. Contains 5 video demonstrations on creating a virtual store, and practice on the same topic as the 5 demonstration videos. If learners don't pass, they can go back and watch the video and come back to do the exercises again. The learners can access the ecosystem anywhere, anytime, and all the time wanting to develop myself. Finally, innovative entrepreneurial thinking skills were assessed. From learners work with a 5-aspect assessment consisting of 1) Creativity 2) Problem solving 3) Value creation 4) Presentation 5) Implementation.

Table 1. Experimental research design

Sample group	Before	Experiment	After
E	T ₁	X	T ₂

Note. E means experimental group; X means digital learning ecosystem through metaverse experiences; T₁ means Pre-test; T₂ means Post-test.

4.1 Population and Sample Group

The population is learners at Rajamangala University of Technology Tawan-Ok. The sample group is learners between the ages of 19–25, bachelor's degree, master's degree, regular part, associate part, Rajamangala University of Technology Tawan-Ok. Selected using Purposive Sampling, a total of 30 people according to Cohen (1988).

4.2 Participants

This study was conducted at Rajamangala University of Technology Tawan-Ok, Thailand. with learners from the Faculty of Business Administration and Information Technology A total of 30 people participated. Criteria for selecting participants included 1) studying at an institution that is well equipped to learn with technology; 2) having the necessary learning equipment for the experiment, such as a tablet computer and Wi-Fi internet.

4.3 Research Tools

1) The expert-approved digital learning ecosystem through metaverse experiences, was found to be suitable and could be used in teaching and learning ($M = 4.73$, $SD = 0.46$).

2) Self-assessment form for pre-test post-test modern digital entrepreneur competencies is a test of 26 questions. Questions that have been evaluated for the consistency of the questions with the learning objectives (Index of Objective Congruence: IOC). Select questions with a congruence value of more than 0.50. The obtained data was analyzed to find the discriminant power of each item or the correlation value. Between the score of each question item and the total score of the remaining items (Item total correlation), select only question items with a discriminant power value greater than 0.3. Question items passing the discriminant power criteria were analyzed to find internal consistency of each aspect of the questionnaire or confidence values by finding the alpha coefficient. (α -Coefficient) of Cronbach, L. Joseph (1984), which should have a confidence value of 0.7 or more. Review and make final corrections before applying to the sample. The assessment developed and improved according to the recommendations of experts was tested with an experimental group of 30 people. Its properties were similar to the sample group. To check the accuracy of the questionnaire using Cronbach's alpha-coefficient, which was found to be .92.

3) Assessment of entrepreneur innovation skills in 5 areas 1. Creativity 2. Problem solving 3. Value creation 4. Presentation 5. Implementation. Evaluated for the consistency of the questions with the learning objectives (Index of Objective Congruence: IOC). The developed and improved checklist form according to the experts'

recommendations was tested for internal conformity, which resulted in a positive statistically significant pearson correlation coefficient at .05 (.75).

4.4 Data Collection and Data Analysis

1) In this research, the researcher analyzed the data and statistics used to analyze the data. Data were analyzed using comparative analysis of difference scores from pretest posttest of learning participation with independent t-tests (Dependent sample t-test) and finding the size of the effect (Effect size: d).

The interpretation criteria are as follows (Cohen, 1988; Hopkins, 2002).

d = 0.10 means there is a very small effect.

d = 0.20 means there is a small effect.

d = 0.50 means there is a medium effect size.

d = 0.80 means there is a large effect.

d = 1.00 means there is a very large effect.

2) Analyze data to compare and contrast scores for evaluating 5 entrepreneurial innovation skills 1. Creativity 2. Problem solving 3. Value creation 4. Presentation, and 5. Implementation one-way repeated measures analysis of variance was used.

3) Including analyzing data from evaluation forms by experts. using frequency, percentage, and standard deviation.

4.5 Research Procedures

The research process is divided into three phases according to the research objectives.

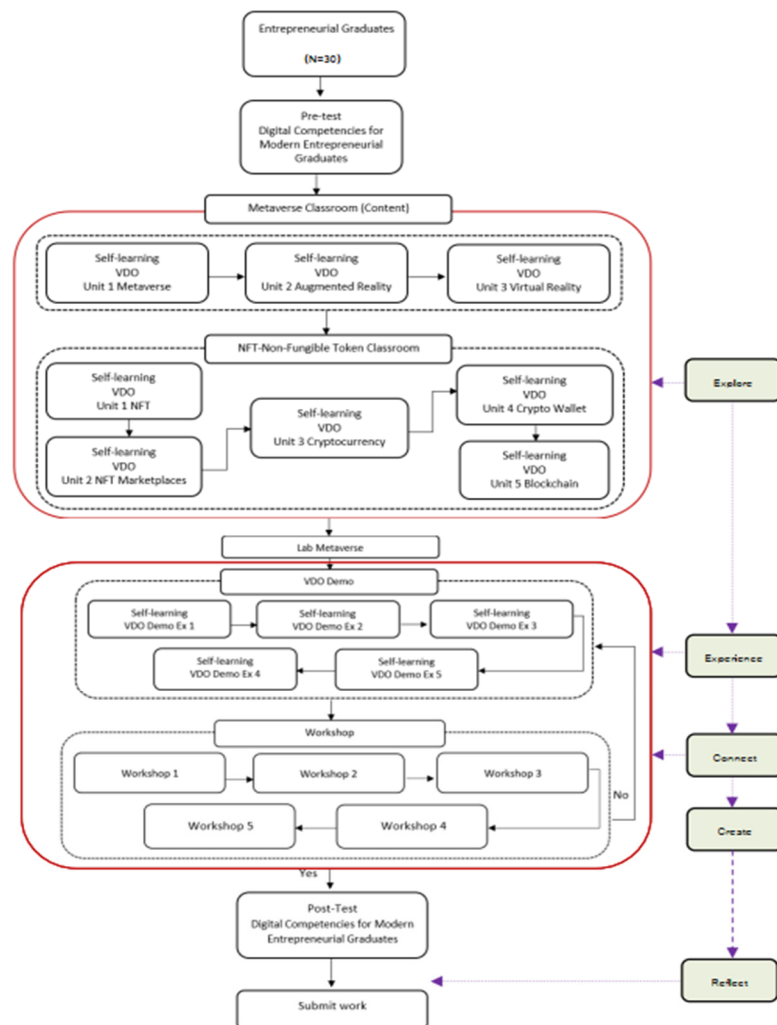


Figure 2. Diagram of metaverse experience for modern digital entrepreneurs competencies

Phase 1) This phase consists of study theories and articles to select and classify related research. Synthesize the reviewed documents into a conceptual framework that includes elements of learning experience design (LXD) process and characteristics of modern digital entrepreneurs’ competencies in metaverse. Set learning objectives Consider the goals of modern digital entrepreneurs’ competencies to plan the design of the learning management process.

Phase 2) Design and develop a model that focuses on the digital learning ecosystem through metaverse experiences. The tool used to develop the learning management model is spatial.io. The suitability of the model was assessed by a total of twelve experts, divided into areas. study digital technology multimedia technology evaluated in the following areas: 1) teaching and learning activities 2) digital learning ecosystem 3) overall system components promoting learning engagement. Consider checking the consistency of the content and activities to see if they cover the learning objectives or not. Suitability of activity formats and other suggestions for improvement and correction of shortcomings by experts.

Phase 3) Study the results of the digital learning ecosystem through metaverse experiences.

Steps of education with a learning ecosystem It consists of learners entering the learning ecosystem. Learn the instructions for using the ecosystem from the video. Take a test before studying the content. After that, study the content that the teacher has prepared in advance, namely the Metaverse classroom, which consists of 3 sub-units: Unit 1 Metaverse, Unit 2 AR, Unit 3 VR. After that, study the NFT classroom Consists of Unit 1 NFT, Unit 2 NFT Market, Unit 3 Cryptocurrency, Unit 4 Crypto Wallet and Unit 5 Blockchain. When studying knowledge related to being a modern entrepreneur It is the process of making a lab metaverse. Inside the lab consists of 1. Watch the demo video. Metaverse implementation is divided into 5 sub-exercises related to digital entrepreneurs. After watching the demo video, it is a step where students must practice on their own by practicing through the platform that the instructor has developed. It was developed from an interactive media creation program. In the process of self-practice If the learner does not follow the steps studied in the demonstration video Learners can go back and view the steps in the demonstration video at any time. And come back to practice and pass all 5 exercises at any time. After that, students review their knowledge by doing mini-exercises. Take a test after class and submit metaverse development work with desired businesses.

5. Results

5.1 Results of Study the Digital Learning Ecosystem Through Metaverse Experiences

The first phase involved studying the digital learning ecosystem through metaverse experiences show in Table 2–3 as follows:

Table 2. Synthesis of the elements of learning experience design (LXD)

Elements of learning experience design (LXD) process									
	(AbuKhoua, 2023)	(López-Belmonte et al., 2023)	(Sá & Serpa, 2023)	(Boonrat Plangsorn, 2023)	(Martin Ebner et al., 2022)	(Yasin Mohammed Ali & Reda Darge Negasi, 2021)	(Ewa Badzińska, 2019)	(Hasan, Kujjah., 2023)	This Research
1. Planning and preparation	/	/	/	/	/	/	/	/	/
2. Design and content development	/	/	/	/	/	/	/	/	/
3. Learners preparation	/	/	/	/	/	/	/	/	/
4. Conducting the teaching activity	/	/	/	/	/	/	/	/	/
5. Assessment and feedback	/	/	/	/	/	/	/	/	/

According to Table 2, steps for educators to design learning activities consist of 1) Planning and preparation, including analyzing learners’ groups and learning goals. 2) Designing and developing content, including creating virtual environments. 3) Learners preparation, preparing learners for the Metaverse. 4) Conducting the teaching activities in the virtual environment. 5) Assessment and feedback, evaluating learning outcomes and providing suggestions.

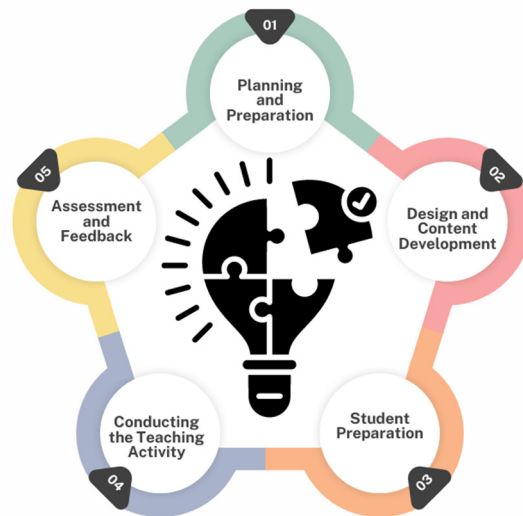


Figure 3. Elements of learning experience design (LXD)

Table 3. Synthesis of characteristics of modern digital entrepreneurs’ competencies

Characteristics of modern digital entrepreneurs’ competencies in metaverse	(Raxmatullaeva et al., 2023)	(Olga, A. et al., 2021)	(Papageorgiou et al., 2021)	(Jardim, 2021)	(Fatemeh, et al., 2022)	(Metaverse, 2022)	(Markopoulos et al., 2022)	(Aysun et al., 2022)	This Research
1. Virtual Reality (VR) and Augmented Reality (AR) skills	/				/	/	/	/	/
2. Immersive experience design	/				/	/	/	/	/
3. Digital marketing in virtual spaces	/	/	/	/	/	/	/	/	/
4. Social media and community engagement		/	/	/	/	/	/	/	/
5. E-commerce and Virtual transactions					/		/	/	/
6. Virtual collaboration and remote work		/					/	/	/
7. Data analytics and Insights	/	/			/	/	/	/	/
8. Blockchain and digital security							/	/	/
9. Content creation and management			/	/	/	/	/	/	/
10. Entrepreneurial mindset and innovation	/	/	/	/	/	/	/	/	/
11. Ethical and legal awareness				/					

According to Table 3, the characteristics of modern graduate entrepreneurs in Metaverse include: 1) Virtual reality (VR) and augmented reality (AR) skills. These skills are essential in helping graduates create and manage virtual experiences. 2) Digital marketing in the virtual space implementing digital marketing strategies in the Metaverse 3) Community and social media engagement 4) Data analysis and insights ability to collect and analyze data from interactions in the metaverse. 5) Content creation and management. Ability to create and manage content in a virtual environment 6) Entrepreneurial mindset and innovation having ideas and innovations in business.

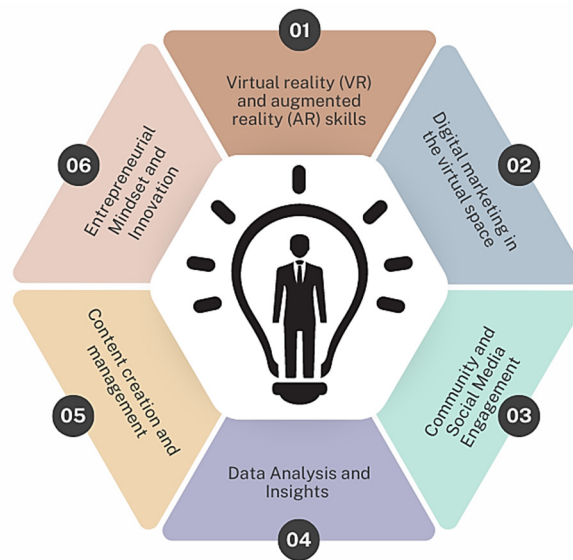


Figure 4. The characteristics of modern digital entrepreneurs’ competencies

Figure 4, characteristics of modern digital entrepreneurs’ competencies in metaverse. Consists of 6 main factors as follows: 1) Virtual Reality (VR) and Augmented Reality (AR) skills to create engaging experiences and develop new products or services. 2) Digital marketing in the virtual space using digital marketing strategies to reach and build relationships with customers in the virtual world. 3) Community and social media engagement community engagement and social media building and maintaining relationships with the community and using social media to build engagement and relationships. 4) Data analysis and insights data analysis and insights collecting and analyzing data to find insights that are useful for making business decisions. 5) Content creation and management content creation and management quality content to interest and engage customers. And 6) Entrepreneurial mindset and innovation entrepreneurship and innovation mindset developing attitudes and skills that enable entrepreneurs to innovate and introduce new innovations to gain a competitive advantage.

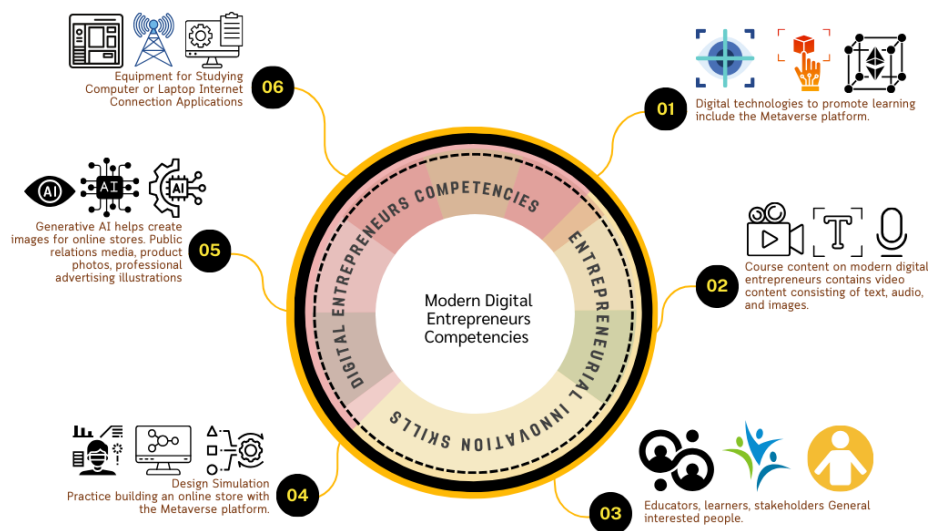


Figure 5. Element of digital learning ecosystem through metaverse experiences

Figure 5, shows the components of digital learning ecosystem through metaverse experiences, consisting of: 1) Digital technology to promote learning including the metaverse platform. 2) The content of the modern digital entrepreneur course consists of video content with text, audio, and picture 3) Ecosystem users consisting of

educators, learners, and stakeholders and those interested in the general public. 4) Simulation practice in designing and creating online stores with the metaverse platform. 5) Generative AI helps create images for online stores. Public relations media, product photos, professional advertising image, and 6) Equipment for studying the use of a computer or laptop's internet connection.

5.2 Results of Design and Develop a Digital Learning Ecosystem Through a Metaverse Experience

The second phase, develop and evaluated for its effectiveness by twelve experts using a suitability assessment form show in Tables 4–5 as follows:

Table 4. Digital learning ecosystem through metaverse experience



According to Table 4, digital learning ecosystem through metaverse experiences consists of 5 main steps:

- 1) *Explore*: Seeking out and researching new information through experimentation or observation to gain a deeper understanding of the content,
- 2) *Experience*: Learning through direct experiences, which helps learners understand

and remember the material more effectively, 3) *Connect*: Linking new information or ideas to existing knowledge or experiences to build a more comprehensive understanding, 4) *Create*: Applying learned knowledge to create something new, such as a project, artwork, or product, And 5) *Reflect*: Reviewing and evaluating one's own learning process to consider how the acquired knowledge can be useful and applied in the future.

Table 5. The mean from the survey on digital learning ecosystem through metaverse experiences

Assessment items	<i>M</i>	<i>SD</i>	Interpretation
<i>Teaching and Learning activities</i>			
Step 1 Explore: seeking knowledge and new information.	4.75	0.45	Highest
Step 2 Experience: actually, doing it and experiencing it directly.	4.58	0.51	Highest
Step 3 Connect: linking new knowledge and experiences with previous knowledge and experiences. Learners analyze data and interpret previous knowledge from online purchasing experiences. together with lesson content theory	4.67	0.49	Highest
Step 4 Create: applying knowledge and experience to create something new.	4.83	0.39	Highest
Step 5 Reflect: thinking back on past experiences to learn and apply in the future.	4.83	0.39	Highest
<i>Digital Learning Ecosystem</i>			
1. Digital technologies to promote learning include the Metaverse platform.	4.67	0.49	Highest
2. Course content on modern digital entrepreneurs contains video content consisting of text, audio, and images.	4.50	0.52	Highest
3. Educators, learners, stakeholder's general interested people.	4.67	0.49	Highest
4. Design simulation practice building an online store with the metaverse platform.	4.75	0.45	Highest
5. Equipment for studying computer or laptop internet connection application.	4.83	0.29	Highest
6. Generative AI helps create images for online stores.	4.92	0.39	Highest
<i>Overall system components promoting learning engagement</i>			
1. Appropriateness of the principles concepts and theories used as a basis for ecosystem development, etc.	4.83	0.49	Highest
2. Objectives of the ecosystem it is appropriate to the principles and concepts of ecological development.	4.67	0.65	Highest
3. Suitability of ecosystem components, etc.	4.58	0.67	Highest
Total	4.73	0.46	Highest

Note. N=12.

Table 5, the results of the expert evaluation of the entire digital learning ecosystem. and the overall system components that promote the highest level of engagement in learning. with a total mean score of 4.73 and standard deviation of 0.46

5.3 Results of Using the Digital Learning Ecosystem Through Metaverse Experiences

The third phase examined the outcomes of using the digital learning ecosystem through metaverse experiences, focusing on digital entrepreneurs' competencies and innovative thinking skills.

1) Comparison of modern digital entrepreneurs' competencies with the analysis is divided into two parts: ① Examination of normal distribution assumptions ② Comparison of the mean differences before and after learning with a digital learning ecosystem through metaverse experiences. The analysis details show in Table 6–7 are as follows: For examining the normal distribution of the variables, skewness and kurtosis values of the data are considered. Curran and colleagues suggested that if the absolute value of the skewness index is greater than 3, the data is highly asymmetric or skewed. Furthermore, if the absolute value of the kurtosis index is greater than 10, the data does not follow a normal distribution (Curran & Finch, 1997). The data examined for normal distribution includes the differences between pre-test and post-test results.

Table 6. Skewness and kurtosis indices of the differences between pre-test and post-test using the digital learning ecosystem through metaverse experiences (N=30)

Item	Pre-test			Post-test		
	\bar{x}	SD	%	\bar{x}	SD	%
Metaverse (3)	0.544	0.506	54.44	0.811	0.388	76.66
Augmented Reality (4)	0.558	0.498	55.83	0.800	0.3951	76.66
Virtual Reality (4)	0.492	0.503	49.17	0.825	0.3801	73.33
NFT Marketplaces (5)	0.440	0.502	44.00	0.820	0.3704	80.00
Cryptocurrency (6)	0.539	0.498	53.89	0.844	0.3620	80.00
Blockchain (4)	0.558	0.504	55.83	0.858	0.2904	73.22
Overall (26)	0.519	0.501	51.92	0.826	0.364	76.66

For checking the normal distribution of variables. It considers the skewness (Skewness) and kurtosis (Kurtosis) values of the data. Curran et al suggested that If the absolute value of the Skewness index is greater than 3, it means that the data is not symmetrical or highly skewed. And if the absolute value of A kurtosis index greater than 10 indicates that the data is not normally distributed (Curran & Finch 1997, p. 91). For the data used to check for normal distribution, it is the difference between before studying and after studying for each variable.

Table 7. Skewness and kurtosis indices of the differences between pre-test and post-test using the digital learning ecosystem through metaverse experiences (N=30)

Item	Skewness	Kurtosis	Distribution
Metaverse	0.757	0.445	normal
Augmented Reality	0.066	-1.633	normal
Virtual Reality	-0.120	-1.664	normal
NFT Marketplaces	-0.400	-0.352	normal
Cryptocurrency	0.642	0.387	normal
Blockchain	0.147	-1.123	normal
Overall	1.092	-3.940	normal

Table 7, the data distribution of the differences between pre-test and post-test shows that the skewness index has a value of -0.400-0.757, which is less than 3, and the kurtosis index has a value of -1.664-0.445, which is less than 10. This indicates that the distribution of the studied variables is normal.

Comparison of the mean differences before and after learning with a digital learning ecosystem through metaverse experiences.

Table 8. Statistical comparison of the differences in modern digital entrepreneurs' competencies before and after learning with a digital learning ecosystem through metaverse experiences

Item	\bar{x}_D	S_D	SE	t	df	Sig.	d
Pre-test – Post test	0.71	0.41	0.075	9.47	29	0.00	1.72

Note. Indicates statistical significance at the .05 level, with a critical t-value of 1.69 (one-tailed).

Table 8, the results of comparing the overall digital entrepreneurs' competencies average scores found that the difference between the average scores after studying and before studying (effect size: d) equal to 1.72, meaning that after studying with the digital learning ecosystem through metaverse experiences, learners had a significantly higher average digital competency score than before studying. Statistically significant at the .05 level, which has a large effect size.

2) Results of the study innovative thinking skills

Table 9. Rubric for evaluating entrepreneurial innovation skills

Level	Creativity	Problem Solving	Value Creation	Presentation	Implementation
Excellent (5)	Exceptional creativity	Innovative problem solving	Exceptional value creation	Professional presentation	Highly effective implementation of ideas
Very Good (4)	High creativity	Excellent problem solving	High value creation	Excellent presentation	Excellent implementation of ideas
Good (3)	Good creativity	Good problem solving	Good value creation	Clear presentation	Good implementation of ideas
Fair (2)	Slight creativity	Partial problem solving	Slight value creation	Average presentation	Minimal implementation of ideas
Improvement (1)	No creativity	Unable to solve problems	Cannot create value	Unclear presentation	Cannot implement ideas

Table 10. Rubric for scoring for innovative thinking from the assessment checklist

Level	Quality of work
5	Work is of very high quality, demonstrates exceptional creativity and innovation, with no errors.
4	Work is of good quality, clearly meets specified objectives, has minor errors that do not affect overall quality.
3	Work is of average quality, meets specified objectives, has some errors impacting quality, but can be improved.
2	Work is below standard, has several errors affecting quality, does not fully meet specified objectives.
1	Work is of very low quality, does not meet specified objectives, has many errors requiring significant improvement.

Table 11. The mean and standard deviation of the innovative thinking from the assessment checklist

Assessment	<i>N</i>	<i>Min</i>	<i>Max</i>	<i>M</i>	<i>SD</i>
1. Creativity	30	2.00	5.00	3.93	0.87
2. Problem solving	30	3.00	5.00	4.07	0.78
3. Value creation	30	3.00	4.00	3.60	0.50
4. Presentation	30	3.00	5.00	4.47	0.57
5. Implementation	30	3.00	5.00	4.10	0.66
Overall Mean	30	3.00	4.80	4.03	0.68

Table 11, the engagement scores from the assessment checklist for innovative thinking with the highest mean value is the 4 presentation ($M = 4.47$; $SD = 0.57$), followed by the 5 implementations ($M = 4.10$; $SD = 0.66$), and the 2-problem solving ($M = 4.07$; $SD = 0.78$).

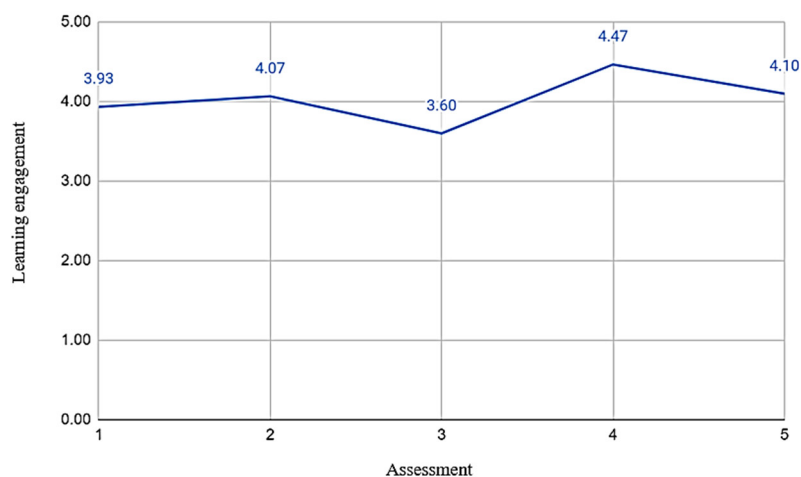


Figure 6. Learning engagement from 1–5 assessment

Figure 6, shows participation in learning developed from five assessment criteria: ① Creativity ② Problem Solving ③ Value Creation ④ Presentation and ⑤ Implementation. From the overall innovative thinking assessment, the average was at a high level ($M = 4.03, SD = 0.68$). The study found that the learning ecosystem helps promote innovative thinking skills for modern digital entrepreneurs.

Table 12. The results of a pairwise comparison of the engagement scores from the assessment checklist for entrepreneurial innovation skills rubric between the 1–5 assessment using one-way repeated measure ANOVA

Assessment		Mean Difference	SE	P	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	0.133	0.251	0.945	-0.359	0.626
1	3	-0.333	0.251	0.338	-0.826	0.159
1	4	0.533	0.251	0.027	0.041	1.026
1	5	0.167	0.251	0.883	-0.326	0.659
2	3	-0.467	0.251	0.072	-0.959	0.026
2	4	0.400	0.251	0.170	-0.092	0.892
2	5	0.033	0.251	1.000	-0.459	0.526
3	4	0.867	0.251	0.000	0.374	1.359
3	5	0.500	0.251	0.045	0.008	0.992
4	5	-0.367	0.251	0.245	-0.859	0.126

Note. $p < 0.05$.

Table 12, results of Pairwise Comparisons of Assessments. The analysis of pairwise comparisons among assessments revealed statistically significant differences as follows

Assessment 1 vs. Assessment 4: The mean difference between Assessment 1 and Assessment 4 was 0.533, which was statistically significant with a p-value of 0.027. This indicates that there is a significant difference in the mean scores between these two assessments.

Assessment 3 vs. Assessment 4: The mean difference between Assessment 3 and Assessment 4 was 0.867, which was highly statistically significant with a p-value of 0.000. This suggests a strong and significant difference in the mean scores between these two assessments.

Assessment 3 vs. Assessment 5: The mean difference between Assessment 3 and Assessment 5 was 0.500, with a p-value of 0.045. This demonstrates that there is a significant difference in the mean scores between these two assessments as well.



Figure 7. Examples of work

Figure 7, the example of work begins with learners naming their own brand. It consists of steps: ① learners start by naming their own brand, establishing a unique identity for their business. ② they then design a logo that represents their brand, focusing on visual identity and brand recognition. ③ learners create innovative new products that are envisioned for the future, highlighting creativity and forward-thinking. ④ the final step involves launching these new products in the metaverse, providing an immersive and interactive platform for introducing their innovations to the market. This process images the comprehensive approach to developing modern digital entrepreneurship skills through practical and creative tasks within a metaverse environment.

6. Discussion and Conclusion

The discussion section of this study examines the outcomes of implementing a digital learning ecosystem through metaverse experiences to enhance modern digital entrepreneurs' competencies. The results from the study indicate several significant findings and implications for educational practices, particularly in the realm of digital entrepreneurship education.

The discussion section of this study examines the outcomes of implementing a digital learning ecosystem through metaverse experiences to enhance modern digital entrepreneurs' competencies. The results from the study indicate several significant findings and implications for educational practices, particularly in the realm of digital entrepreneurship education.

1) The results of the expert evaluation found that the entire digital learning ecosystem and the overall system components that promote the highest level of engagement in learning. with a total mean score of 4.73 and standard deviation of 0.46.

2) the results of comparing the overall digital entrepreneurs' competencies average scores found that the difference between the average scores after studying and before studying (effect size: d) equal to 1.72, meaning that after studying with the digital learning ecosystem through metaverse experiences, learners had a significantly higher average digital competency score than before studying. Statistically significant at the .05 level, which has a large effect size suggesting that the intervention had a substantial impact on improving learners' competencies.

3) the results of the pairwise comparison using one-way repeated measure ANOVA show that the mean difference between assessments 1 and 4 (0.533 , $p = 0.027$), assessments 3 and 4 (0.867 $p = 0.000$) and assessments 3 and 5 (0.500 $p = 0.045$) are statistically significant at the 0.05 level.

The innovative thinking skills of learners were also enhanced, as reflected in the high mean scores for various aspects such as creativity, problem-solving, value creation, presentation, and implementation. The Metaverse environment provided a platform for learners to explore and develop these skills in a more engaging and practical manner. The use of Metaverse experiences led to higher levels of learner's engagement. The immersive and interactive nature of the Metaverse encouraged active participation, exploration, and hands-on learning, which are critical for effective learning and skill development. The digital learning ecosystem through metaverse experiences developed by the researcher contains content related to being an entrepreneur in the digital age, consisting of 5 units. The educational steps are as follows:

- ① Learners must take a pre-class test to measure basic knowledge before studying the content.
- ② The next step is for learners to study a demonstration video consisting of 5 exercises divided into steps.
- ③ After that, learners practice same in the video. If the learners do not pass the practice, they must watch the demonstration video again and then returns to practice until they pass.
- ④ There are exercises for reviewing the content before taking the post-test.
- ⑤ Finally, learners submit their work of creating a store in the virtual world.

The ecosystem developed by the researchers can be accessed at any time the learner wants to study. As a result, after studying with the ecosystem, post-study scores were significantly higher than pre-study scores at the .05 level, in line with the set assumptions. Additionally, the average score from evaluating work using a Rubric Score compared 5 areas of entrepreneurial innovation skills: 1) Creativity, 2) Problem-solving, 3) Value creation, 4) Presentation, and 5) Implementation. The research found a statistically significant difference at the .05 level in these areas, demonstrating the potential of a digital learning ecosystem through Metaverse experiences in enhancing modern digital entrepreneurs' competencies. The significant improvements in digital skills, innovative thinking, and learner's engagement underscore the effectiveness of this approach. As educational landscapes continue to evolve, integrating immersive and interactive technologies like the Metaverse will be crucial in preparing learners for the demands of the digital economy. From the results of the research, it can be concluded that the digital learning ecosystem through metaverse experiences is suitable for developing Modern Digital

Entrepreneurs Competencies and Entrepreneurs' innovation skills. This conclusion aligns with the research of Shivani Inder (2022), who studied the Metaverse as presenting significant opportunities for entrepreneurs in various sectors such as digital marketing, advertising, gaming, education, and tourism. These opportunities lead to changes in business practices and reduce social inequality (Shivani Inder, 2022). Additionally, the research by Khandaker et al. (2023) studied the potential of Metaverse technology to revolutionize education by offering a high-quality and sustainable learning experience. Metaverse technology provides a transformative approach to education by using augmented reality to revolutionize the learning experience (Khandaker et al., 2023).

7. Recommendation

- 1) The findings suggest that integrating Metaverse experiences into educational practices can significantly enhance the learning outcomes for digital entrepreneurship programs. Educators should consider adopting such innovative technologies to create more engaging and effective learning environments.
- 2) The success of the digital learning ecosystem through Metaverse experiences highlights the importance of designing curricula that incorporate experiential and immersive learning opportunities. Curriculum developers should integrate VR, AR, and other advanced technologies to provide learners with practical, real-world experiences.
- 3) Further research is needed to explore the long-term impact of Metaverse-based learning on various educational outcomes. Additionally, studies could investigate the effectiveness of different components of the Metaverse ecosystem and their specific contributions to learning and skill development.
- 4) Educational institutions and policymakers should support the integration of advanced digital technologies into teaching and learning processes. Providing adequate resources, training, and infrastructure is essential to successfully implement such innovative educational strategies.

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Competing interests

Not applicable.

Informed consent

Obtained.

Ethics approval

This research has been approved by the Human Research Ethics Committee under the code COA.ID 030/2566.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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