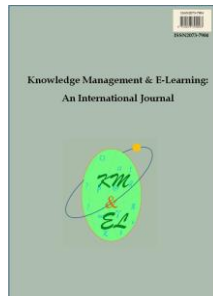

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The use of virtual reality for skill development in entrepreneurship education: A systematic literature review

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Abstract: Rapid technological advances have transformed the entrepreneurial landscape, while growing demand for flexible, experiential learning has reshaped both the development of entrepreneurial competencies and the delivery of entrepreneurship education. These global shifts in education have led instructors to explore emerging technologies such as virtual reality (VR) to engage learners and provide safe, flexible opportunities for experiential learning and skill development. This systematic literature review examines the use of VR in entrepreneurship education from 2013 to 2024. The review aimed to identify how VR technologies have been used to support entrepreneurial skill development, the types of VR employed, and the specific skills targeted. Peer-reviewed articles in English were screened for relevance to immersive learning and skill development. Twenty-three studies met the inclusion criteria and were analysed using the PRISMA framework. Findings indicate that VR interventions with varying levels of immersion can effectively support entrepreneurial skill development. Factors contributing to successful outcomes include integration into a program of learning, instructor involvement, grounding in sound pedagogical principles, and alignment with intended learning outcomes. High mobility, interactivity, and immersion enhance learning, while social features foster collaboration. Less immersive serious games offer accessible, cost-effective alternatives. Although VR has supported the development of competencies across the EntreComp framework, those in the Ideas and Opportunities category are underrepresented, particularly in immersive formats. Limitations include database scope, timeframe, and single-reviewer analysis. Future research should explore the use of the EntreComp Questionnaire for assessment, the potential of virtual worlds, and the role of artificial intelligence in enhancing VR-based entrepreneurship education.

Keywords: Virtual reality; Higher education; Entrepreneurship education; EntreComp competencies; Entrepreneurial skills

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Dr. Avgoustos Tsinakos is a Professor and Director of Advanced Educational Technologies and Mobile Applications (AETMA) Lab in the Department of Computing Science at Democritus University of Thrace and former Director of the International MSc in Immersive Technologies in Education, Training and Game Design. He was/is coordinator (or member of the coordination team) in more than 32 national/international programs related to immersive technologies, distance education and technology enhanced learning. Moreover, he collaborates scientifically with several universities in USA, Spain, Canada, the Netherlands and China but also with government bodies such as the Prosecution of Electronic Crime in Greece. His publication list includes four books in English and one in Chinese, four book chapters, more than 150 papers on the topic of technology enhanced learning, immersive technologies, XR and AI. In addition, Prof Tsinakos has participated in more than 90 world/international/national conferences as invited speaker/presenter.

1. Introduction

Rapid technological advances have transformed the entrepreneurial landscape, creating new demands for flexible, experiential learning approaches in higher education. Entrepreneurship education has shifted from emphasizing innate traits to fostering skills that can be developed through structured, reflective learning experiences. Skills such as communication, planning, and mobilizing resources are increasingly critical for graduates navigating innovation-driven economies. To meet these needs, educators have explored emerging technologies that enable active, learner-centred engagement.

Virtual reality (VR) offers unique affordances for experiential learning by immersing students in interactive environments where they can practice entrepreneurial tasks in low-risk settings. VR can enhance motivation, deepen understanding, and support skill development through authentic simulations. However, limited research has systematically examined how VR is being applied in entrepreneurship education, what types of VR technologies are used, and which entrepreneurial skills they address. This review aims to synthesize existing studies to provide a clearer picture of current practices and inform future instructional design.

2. Theoretical background

To conduct the proposed review effectively, it is important to understand past developments in entrepreneurship education, underlying pedagogies, and the use of VR as an educational technology to support the development of skills and competencies.

2.1. Entrepreneurship education foundations, focus, and pedagogy

Early research in entrepreneurship education suggested that entrepreneurial success was dependent on innate traits. Subsequent evidence has demonstrated that it is more directly associated with the development of entrepreneurial skills (Lyons et al., 2021; Neck & Greene, 2012). To promote lifelong entrepreneurial development, the European Commission published EntreComp: The Entrepreneurship Competence Framework (Bacigalupo et al., 2016). This framework identifies competencies and skills that contribute to entrepreneurial success, dividing them into three categories: Ideas and Opportunities, Resources, and Into Action (see Table 1). Čopková et al. (2023) provide an associated assessment tool, the EntreComp Questionnaire, which can be used by entrepreneurs for ongoing self-assessment.

Table 1
EntreComp categories and competencies

Category	Competencies
Ideas and Opportunities	Spotting Opportunities, Creativity, Vision, Valuing Ideas, Ethical and Sustainable Thinking
Personal Resources	Self-Awareness and Self-Efficacy, Motivation and Perseverance, Mobilizing Resources, Financial and Economic Literacy, Mobilizing Others
Into Action	Taking the Initiative, Planning and Management, Coping with Uncertainty, Ambiguity, and Risk, Working with Others, Learning through Experience

Note. Adapted from Bacigalupo et al. (2016)

As entrepreneurship education has shifted to focus on developing skills and competencies, experiential learning has been widely adopted (Kozlinska et al., 2023). This learner-centred approach is grounded in constructivism, a paradigm in which learners actively engage with new information to construct knowledge through meaningful tasks and contextual feedback (Rodrigues, 2023). Constructivism emphasizes active participation and reflection, which are essential for developing entrepreneurial competencies.

Experiential Learning Theory (ELT), developed by Kolb (1984), builds on constructivist principles and describes a four-stage cycle: concrete experience, reflective observation, abstract conceptualization, and active experimentation. This cycle enables learners to engage in entrepreneurial challenges and apply insights to strengthen their competencies. Experiential learning has been described as the “*key to empowering students to... succeed in entrepreneurship*” (Rodrigues, 2023).

While experiential learning effectively increases entrepreneurial knowledge and skills for students with entrepreneurial inclinations, traditional pedagogy, such as lectures, seminars, and classroom-based activities, remains crucial for introducing foundational concepts and fostering entrepreneurship in broader student populations (Kozlinska et al., 2023). Instructors are encouraged to integrate both approaches to maximize learning outcomes.

2.2. Virtual reality to support entrepreneurship education

Extended reality (XR) is a powerful tool for experiential learning, enabling students to engage with content through immersive, hands-on experiences in simulated, multisensory environments. XR includes a range of immersive technologies, such as augmented reality (AR), which overlays virtual objects onto the learner's environment; virtual reality (VR), which immerses the learner in an artificial environment; and mixed reality (MR), which enables users to interact with virtual elements within their physical environment (Bates, 2022). The metaverse is a network of immersive online worlds where users interact and purchase goods and services (Gregersen, 2025). This review focuses on VR experiences, categorized by level of immersion.

Non-immersive VR (e.g., 360° photos and 3D video games) is most accessible and affordable since it can be used on mobile phones, tablets, laptops, or desktop computers. Semi-immersive VR systems (e.g., flight simulators or full-room 3D displays) use screens or wall projections to immerse users in an artificial environment. Fully immersive VR systems (e.g., Meta Quest 3 and HTC Vive Focus Vision) isolate the user from the real world using a head-mounted device (HMD) that delivers audio and visual inputs, creating a strong sense of presence (the feeling of being physically present in the virtual environment). Additional handheld controllers allow users to interact with virtual objects and other users. More complex interactions can incorporate tactile and olfactory elements.

Each level of immersion in VR presents unique opportunities for learners to engage with content and develop skills and competencies. Less immersive interventions allow students to develop knowledge and solve problems in 3D learning environments. Interacting with 3D objects can help students better understand abstract concepts and complex content (Nesenbergs et al., 2021). Karabina et al. (2023) found their students generally valued the simplicity of less immersive learning experiences, but for specific topics, they preferred higher levels of immersion, which minimized external distractions, allowed them to feel more connected to their learning, and enhanced their ability to visualize and interact with 3D objects.

In contrast, fully immersive simulations can more accurately emulate real-world scenarios, allowing students to practice complex skills or procedures (Xin et al., 2019) or respond effectively to high-pressure or dangerous situations within a low-risk environment (Berthiaume et al., 2024). Their increased vividness and interactivity can enhance learning and retention (Halabieh, 2022), but accessibility can be reduced by high development and equipment costs. Increased cognitive load and cybersickness may also limit accessibility if appropriate preventative strategies are not employed (Mayer, 2009; Weech et al., 2019).

Avatar-based VR experiences can facilitate interaction, collaboration, and community building across distances, benefiting online learners and those seeking connection with a learning community (De Ponti et al., 2020; Nesenbergs et al., 2021). Learning anonymously as avatars can also enhance students' sense of emotional safety when practicing skills in front of their peers (Sholihin et al., 2020).

To optimize learning, VR experiences must be designed, selected, and used in alignment with sound pedagogical principles (Radianti et al., 2020) and guided by an educational professional (Bates, 2022). These principles ensure that technology serves learning objectives rather than overshadowing them, promoting meaningful engagement and skill development. Building on the work of Long and Tsinakos (2021), Karabina et al. (2023) have developed a tri-part framework of best practices to support these processes.

3. Related work

Several prior reviews have explored the role of educational technologies in entrepreneurship education, though none have focused specifically on the use of virtual reality (VR) for entrepreneurial skill development. Hammada (2024) examined the impact of various technologies on EntreComp competencies, referencing VR's potential to enhance students' self-awareness and their ability to cope with ambiguity and risk. Chen et al. (2021) and Juliana et al. (2022) discussed the value of serious games in entrepreneurship and business education yet did not address immersive VR applications.

Cai (2024) investigated metaverse-based learning in business courses, identifying improvements in problem-solving and self-efficacy, but offered limited insight into broader entrepreneurial skill development. Dong and Tu (2021) and Maydiantoro et al. (2023) explored VR's influence on entrepreneurial intention and willingness, rather than its role in skill acquisition. Yasin et al. (2022) and Fox et al. (2018) provided overlapping lists of serious games that complement entrepreneurship education. Yasin et al. summarized the topics addressed by these games, while Fox et al. highlighted the modes of learning they support. However, both studies focused on non-immersive technologies and did not examine more immersive VR applications.

Collectively, these investigations underscore the growing interest in digital tools for entrepreneurship education but reveal a clear gap: no comprehensive review has examined how different forms of VR (non-immersive, semi-immersive, and fully immersive) are being used to develop entrepreneurial skills. Addressing this gap is essential for understanding current practices and guiding future instructional design.

Accordingly, this review examines the use of VR technologies in entrepreneurship education between 2013 and 2024 and aims to answer the following research questions:

RQ1: How have virtual reality technologies been used to support entrepreneurial skill development?

RQ2: What types of virtual reality have been used to develop entrepreneurial skills?

RQ3: What entrepreneurial skills have been developed using virtual reality?

4. Methods

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure a comprehensive and unbiased review of relevant studies. More specifically, this review used the original PRISMA Statement developed to update the earlier QUOROM Statement (Moher et al., 2009). A flow chart is provided (see Fig. 1), and each phase of the process is described.

4.1. Identification

Three databases were selected for the initial search: Scopus and IEEE Xplore, chosen for their strong focus on technology, and Google Scholar, selected for its expansive coverage across disciplines. Each database search was limited to articles published in peer-reviewed journals between 2013 and 2024, reflecting the rapid evolution of VR technologies during that time. The following Boolean search string was used across all databases: (("virtual reality" OR "virtual world" OR "immersive learning" OR "virtual simulation" OR "VR"

OR “metaverse”) AND (“entrepreneur” OR “entrepreneurial”) AND (“education” OR “university” OR “college” OR “higher education” OR “skills”)).

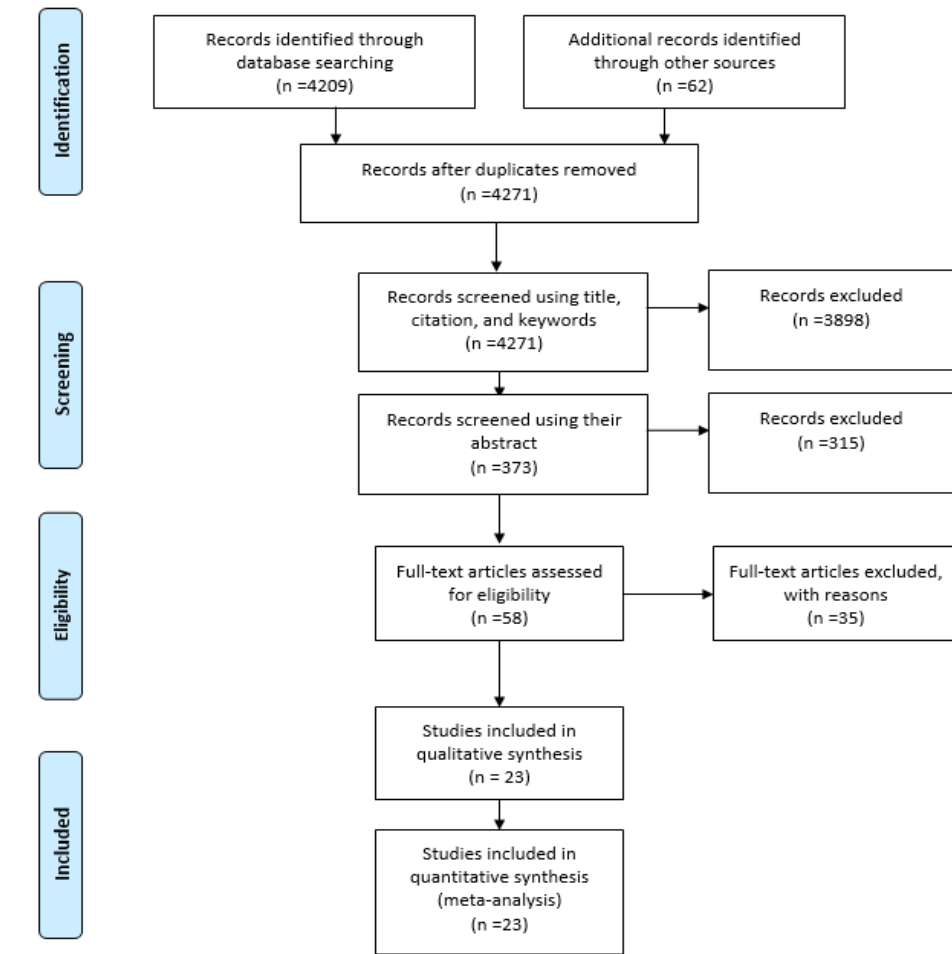


Fig. 1. Systematic review flow chart (Moher et al., 2009)

4.2. Screening

Initial screening involved reviewing article titles, citations, and summary components highlighted by Google Scholar. Articles were excluded if they were conference proceedings or book chapters, not published in peer-reviewed journals, or published prior to 2013. Articles were also excluded if their listing in the database was not in English.

4.3. Eligibility and inclusion

During a subsequent reading of the abstract, followed by a full reading of each paper, additional exclusion criteria were applied. Articles were excluded if the full text was not available, if the full text was not available in English, or if the study did not involve immersive learning. Papers were also excluded if they did not pertain to entrepreneurship.

education or higher education, failed to address skill development, had been retracted, or did not reference peer-reviewed articles.

4.4. Data extraction and analysis

During a second reading of each article, data needed to answer and contextualize the research questions were extracted and tabulated. Extracted elements included the article title, study description, summary of findings, skills developed, cited learning theories, type of VR, level of immersion, mode of access, mobility, interactivity, costs, social features, and citation details. It was also noted whether the intervention was piloted or unpiloted, and whether it was part of a broader learning program. Using the extracted data, relevant relationships were explored.

4.5. Backward and forward reference searching

Articles were also identified using backward and forward searches. The reference lists of eligible papers were searched backward, and the lists of works citing eligible papers were searched forward to identify additional papers of potential interest. Regardless of the identification method, all identified articles were screened and deemed eligible using the same criteria. Results are summarized in Table 2.

Table 2

Individual and summative database search details

Article search process	Google Scholar	Scopus	IEEE Xplore	Total
Publication date	2013-2024	2013-2024	2013-2024	N/A
Articles identified: Database search	3960	241	8	4209
Articles identified: Forward/backward searches	48	14	0	62
Total articles identified	4008	255	8	4271
Articles remaining after title, citation, and highlighted component review	348	25	0	373
Articles remaining after full abstract reading	47	12	0	58
Articles remaining after full paper reading	20	3	0	23
Total articles included	20	3	0	23

5. Results

5.1. Identification

Initially, 3,960 papers were identified through Google Scholar, 241 through Scopus, and 8 through IEEE Xplore. Subsequently, 62 papers were identified through backward searches of references and forward searches of citations. In total, 4,271 articles were identified.

5.2. Screening, eligibility, and inclusion

During the initial screening stage, 4,271 papers were reviewed based on titles, citations, and highlighted components; 3,898 were excluded, and 373 remained. Abstracts were then examined for these 373 articles, resulting in the exclusion of 315 and retention of 58. Next, full texts were assessed for the 58 articles; 35 were excluded, leaving 23 eligible studies. The high exclusion rate was anticipated, primarily due to the requirement that studies

address the development of entrepreneurial skills through VR use or describe the development of a VR platform for entrepreneurship education with the potential to foster such skills. Many excluded articles lacked a clear focus on entrepreneurship or concentrated solely on motivation and engagement without addressing actual or potential skill development.

5.3. Data extraction

All 23 eligible articles were deemed to be of sufficient quality and underwent data extraction.

5.4. Analysis

5.4.1. Types of VR used – level of immersion

Of the twenty-three included articles, nine discussed non-immersive VR, one discussed semi-immersive VR, and thirteen discussed fully immersive VR (see Fig. 2).

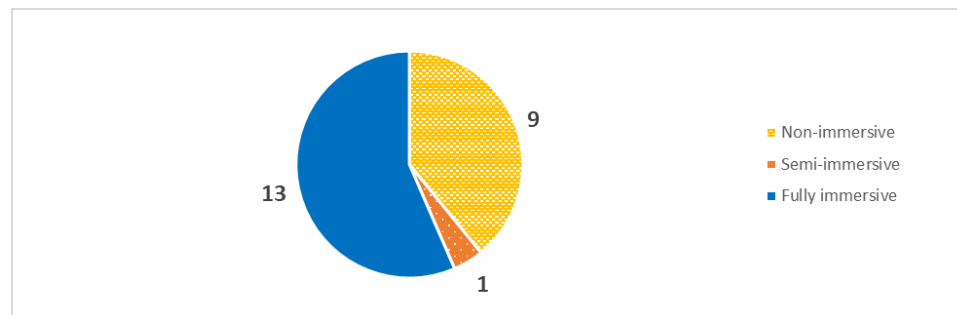


Fig. 2. Types of VR used - level of immersion

Table 3 provides a summary of each included article.

Table 3

Summary of interventions and findings from included articles

No.	Description	Citation
1	Those involved in founding the metaverse-based Indonesian Start-up Creative City were determined to have developed entrepreneurial leadership skills through experiential learning, discussions, mentorship, virtual events, and collegial support.	Novel and Alexandri (2023)
2	Online learners in China engaging in immersive learning and peer interaction in the VR-ILM Smart Space demonstrated increased engagement, satisfaction, and employment.	Pan (2022)
3	Learners in Greece (individually or in groups) experienced increased motivation and enhanced development of entrepreneurial mentality, skills, and competencies after engaging as avatars with lectures, classroom learning, text-based or multimedia modules, non-player characters (NPCs) and interactive, gamified learning activities.	Grivokostopoulou et al. (2019)
4	Students studying in Mexico, assigned a cultural background before engaging as avatars in virtual negotiations and peer observations, developed negotiation skills and reported an increased sense of emotional safety from participating as an avatar.	Hernandez-Pozas and Carreon-Flores (2019)
5	Students engaging in entrepreneurial role-play in Second Life demonstrated enhanced learning outcomes compared to those involved in face-to-face simulations and those participating in online discussions.	Peng and Abdullah (2018)
6	Dutch university students practiced presenting in VR in front of a 100-avatar audience using an in-house application. Equal gains in presentation competence were observed compared to those practicing in a face-to-face setting.	van Ginkel et al. (2019)
7	Early-stage Second Life entrepreneurs were observed and interviewed to assess virtual entrepreneurship as a learning opportunity. As participants identified and acted on business opportunities, they also developed entrepreneurial skills.	Noke and Chesney (2014)

8	Students assigned an elevator pitch practiced using Ovation VR received electronic and in-person feedback, leading to improved presentation skills.	McGovern et al. (2020)
9	Using the Intelligent Mobile Assisted Entrepreneurship Learning System (IMELS), students navigated entrepreneurship education resources in a 3D virtual environment, leading to improved engagement, motivation, and satisfaction.	Zhang (2023)
10	A VR learning space was designed to provide a place for students to interact and collaborate as part of an entrepreneurship education program.	Li et al. (2022)
11	A proposed VR platform aims to engage European agriculture students and support entrepreneurial skill development through multimedia content, 3D simulations, and learning activities. These activities focus on developing ideas, finding funding, and formulating, managing, and improving an agribusiness.	Grivokostopoulou et al. (2020)
12	A proposed virtual city offering resource supply, production, management, and consulting services aims to provide practical entrepreneurship training for Chinese college students. Students can participate in various activities with instructor guidance to enhance their innovative and entrepreneurial skills.	Guan (2020)
13	A proposed VR learning platform for an entrepreneurial education social game where European youth, as avatars, can interact with peers, 3D objects, multimedia content, non-player characters (NPCs) and learning resources.	Ionitescu et al. (2019a)
14	The proposed VR learning platform, available for self-learning and formal education, provides a game-based VR environment where European youth can develop agricultural entrepreneurship skills through peer interaction, multimedia content, 3D simulations, and educational programming.	Ionitescu et al. (2019b)
15	Students in Indonesia assigned to engage with a VR-based ethics learning experience demonstrated increased motivation, interest, and perceived learning effectiveness.	Sholihin et al. (2020)
16	As part of an online Chinese entrepreneurship education program, student teams using virtual simulation games to establish companies, analyse markets, and make financial decisions, experienced increased engagement and skill development.	Yang et al. (2022)
17	Students in an interdisciplinary course who engaged with a cloud-based entrepreneurship serious game for six weeks developed skills related to management, leadership, employee motivation, emotional intelligence, and social dynamics.	Buzady and Almeida (2019)
18	Students engaging with a VR entrepreneurship game developed skills in innovation, leadership, strategic thinking, problem-solving, and risk management.	Almeida (2017a)
19	Students engaging in a VR entrepreneurship game developed a business plan and enhanced their knowledge in entrepreneurship, innovation, and management.	Almeida (2017b)
20	A ten-year review of a German program involving VR simulations and business game competitions demonstrated significant increases in students' business knowledge and entrepreneurship skills. Startup rates were double the usual level.	Kriz and Auchter (2016)
21	Post-secondary institutions in Italy, Spain, and the Netherlands reviewed VR games for use in an entrepreneurship course. The pilot resulted in increased entrepreneurial knowledge and skills.	Antonaci et al. (2015)
22	UK business students engaging in a VR serious game in teams followed by individual reflective journaling developed their entrepreneurial attitudes, values, and skills.	Williams (2015)
23	Universities in Italy, Spain, and the Netherlands reviewed eight serious games for use in entrepreneurship courses that supported development of students' entrepreneurial knowledge and skills.	Bellotti et al. (2014)

5.4.2. *Types of VR used – Mode of access*

The level of immersion experienced by a user depends not only on the design of the VR experience but also on the hardware used to access it. For example, Ovation is a fully immersive VR learning experience that can be accessed using either a head-mounted device (HMD) with hand controllers or a PC, but the level of immersion and sense of presence are higher when using an HMD. For this reason, each article was examined to determine the mode of access used in each intervention.

In Fig. 3 and 4, the mode of access is included in brackets following the immersion level (e.g., FI (HMD) denotes a fully immersive VR experience accessed using a head-mounted device, and SI (PC projected) indicates that a semi-immersive VR experience was accessed using a PC and projected onto a screen). All eight non-immersive serious games (SGs) were accessed using a PC, while a non-immersive VR learning repository was accessed using a mobile device. The single semi-immersive experience was accessed using

a PC that projected images onto a screen. Thirteen fully immersive learning experiences were accessed in various ways: five used HMDs, six used PCs, and two articles did not specify the mode of access.

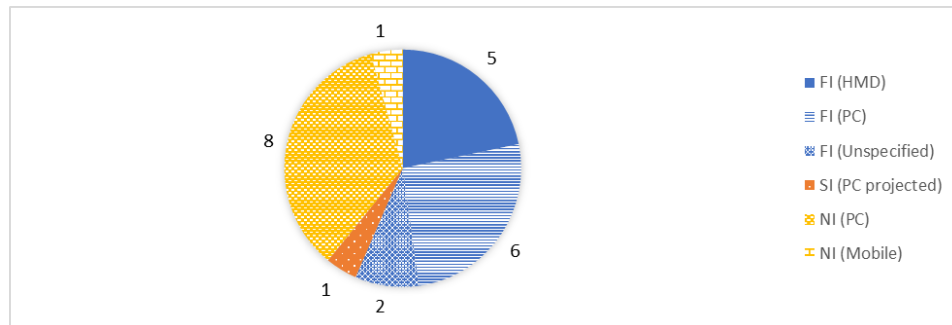


Fig. 3. Types of VR used – level of immersion (mode of access) (FI = fully immersive; SI = semi-immersive; NI = non-immersive; HMD = head-mounted device; PC = personal computer or laptop; PC projected = personal computer projected onto screens; Mobile = mobile device)

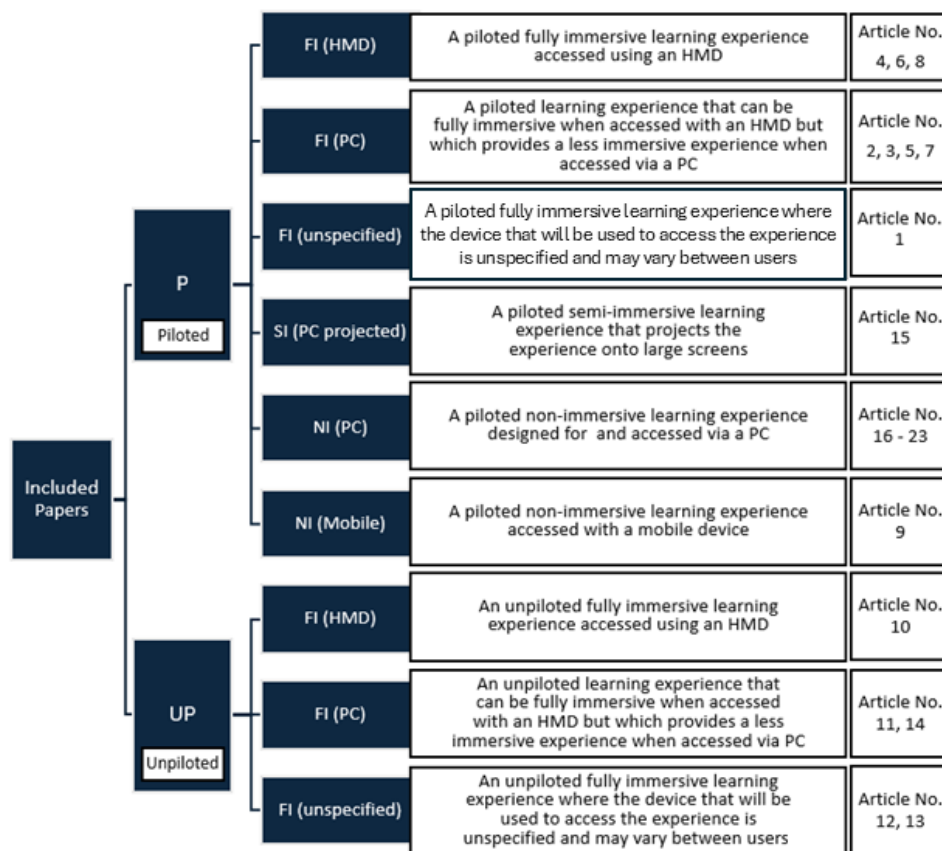


Fig. 4. Piloted and unpiloted VR learning experiences with level of immersion and mode of access (P = piloted; UP = unpiloted; FI = fully immersive; SI = semi-immersive; NI = non-immersive; HMD = head-mounted device; PC = personal computer or laptop; PC projected = personal computer projected onto screens; Mobile = mobile device; SG = serious game)

5.4.3. Piloted and unpiloted

Only eighteen articles describe piloted VR interventions (interventions where students engaged with the VR experience and the learning impact was evaluated). The remaining five articles describe unpiloted interventions. In some cases, intended skill development was discussed, but no evaluation was conducted. In Fig. 4, each article has been categorized first as piloted (P) or unpiloted (UP) and then categorized by level of immersion and mode of access using the same notation as in Fig. 3. Article numbers (as assigned in Table 3) are noted on the right.

5.4.4. Mobility, interactivity, and social features

To deepen the understanding of the types of VR used in entrepreneurship education, this review examined mobility, interactivity, and social features within each VR learning experience (see Table 4). The platform used to host each VR activity was also noted. Definitions for each term are provided below, along with examples of high, moderate, and low ratings where appropriate.

Table 4

Mobility, interactivity, and social features (organized by level of immersion)

Immersion	No.	Mobility	Interactivity	Social features within the VR activity				Platform
				Peer interaction	Peer collaboration / discussion	Mentorship and/or consultations	Events and/or training	
FI	1	H	H	Y	Y	Y	Y	Start-up Creative City
	2	L	M	Y	Y	*	Y	VR-ILM
	3	H	H	Y	Y	Y	Y	Innovative 3D
	4	M	M	Y	Y	*	*	Engage
	5	H	M/H	Y	Y	*	*	Second Life
	6	M	M	*	*	*	*	in-house application
	7	H	H	Y	Y	*	Y	Second Life
	8	H	H	*	*	*	*	Ovation VR
	10^	M	M	Y	*	*	*	Unity 3D
	11^	H	H	Y	Y	*	Y	AGRIENT, OPENSIM
SI	12^	H	H	Y	Y	Y	*	Not specified
	13^	H	H	Y	Y	*	*	BIZ4FUN, OpenSimulator
	14^	H	H	Y	Y	*	*	AGRIENT, OpenSimulator
	15	M	M	*	*	*	*	Not specified
	9	M	M	*	*	*	*	IM-ELS
NI	16	L	M	Y	Y	*	*	Not specified
	17	L	M	*	*	*	*	FLIGBY
	18	L	M	*	*	*	*	Entrexplorer
	19	L	M	*	*	*	*	Entrexplorer
	20	L	M	*	*	*	*	TOPSIM
	21	L	Various	*	*	*	*	START-UP
	22	L	M	*	*	*	*	Various
	23	L	Various	*	*	*	*	SimVenture

Note. ^ = unpiloted interventions; * = nothing within the article indicated this option is available; FI = fully immersive; SI = semi-immersive; NI = non-immersive; H = high; M = moderate; L = low; Y = yes

Mobility refers to the ability to move freely or be transported over distances within a VR experience. High (H) mobility is characterized by users being able to gesture, move their arms, head, and body, run, walk, teleport, or otherwise navigate within the virtual environment, moving easily within and between virtual spaces. Moderate (M) mobility involves movement and gestures confined to a single virtual space. Low (L) mobility indicates minimal movement capabilities, typically limited to head and arm motions with little movement within the virtual space.

Interactivity describes the extent to which learners can engage with elements of the VR environment. High (H) interactivity allows users to handle, move, observe, listen to, and manipulate various virtual components, enabling complex interactions. Moderate (M) interactivity involves simpler forms of engagement, such as speaking with or texting peers. In cases where not enough information was provided to distinguish between moderate and high interactivity, a moderate-high (M/H) rating was assigned. Low (L) interactivity refers to passive engagement, such as watching or listening, with limited opportunities to manipulate elements in the environment.

Social Features refer to aspects of the VR experience that allow learners to engage with others within the virtual environment. These include peer-to-peer communication, group collaboration and discussion, mentorship or consultation opportunities, and participation in virtual events or training sessions. Overall, fully immersive interventions had higher levels of mobility and interactivity and more social features than the non-immersive or semi-immersive interventions.

5.4.5. Portability and associated costs

Each VR application was further examined to assess its portability and associated costs (see Table 5). Portability refers to the ease with which a VR system can be moved or accessed across locations. Systems rated as having high (H) portability are easily transported, allowing access from various locations and potentially even while in motion. Examples include untethered head-mounted displays (HMDs) or mobile phones. Moderate (M) portability applies to VR experiences that are less mobile or require stationary use but still allow access from diverse locations, such as web-based serious games accessible via personal computers. In cases where the available information did not clearly distinguish between moderate and high portability, a moderate-high (M/H) rating was assigned. Low (L) portability refers to systems that are bulky, require extensive setup, or are not easily transported, such as HMDs or PCs tethered to external equipment.

Although none of the reviewed articles provided detailed cost breakdowns, many mentioned or implied expenses related to equipment or associated fees. These costs were categorized into two groups: those borne by students and those incurred by instructors or institutions (see Table 5). In many of the studies, it was unclear which equipment was provided for students and which items they were expected to purchase. However, in most cases, students used PCs or mobile devices, which are tools that many can access easily, while larger expenses, such as head-mounted displays (HMDs), software development, and specialized hardware, were typically covered by instructors or institutions, sometimes with government funding.

In general, the least portable interventions were fully immersive experiences that relied on HMDs or PCs tethered to external equipment. However, advances in wireless technology and hardware miniaturization are rapidly addressing these limitations. For example, modern HMDs, such as the Meta Quest series, no longer require a PC connection

and are significantly more portable than earlier systems. Among the reviewed interventions, the most portable was a non-immersive experience delivered via a mobile phone.

Table 5
Portability and associated costs (organized by level of immersion)

Immersion	No.	Portability	Student/user costs	Instructor/institutional costs
FI	1	M/H	PC/mobile device, start-up costs	PC/mobile device, start-up costs
	2	M	Computer	Robot instructor, cameras, PC, development costs
	3	M	PC	PC, development costs
	4	L	Minimal	HMD, controllers, subscription
	5	M	PC	PC, property in Second Life
	6	L	Minimal	HMD, laptop, microphone, software purchase (Microsoft Kinect Windows), software development
	7	M	PC	N/A
	8	L	Minimal	HMD (Oculus Rift), tether, PC, subscription
	10^	H	Not specified	Development costs, HMD
	11^	M	Not specified	Development costs
	12^	M/H	Not specified	Development costs
	13^	M/H	Not specified	Development costs
	14^	M	PC	Development costs
	15	L	Minimal	PC, projector, screen
SI	9	H	Mobile phone	Development costs
	16	M	PC	Not specified
	17	M	PC	Subscription
	18	M	PC	PCs, subscription
NI	19	M	PC	PCs, subscription
	20	Not specified	PC	PCs, development costs
	21	M	PC	PCs, SG subscriptions/purchases
	22	M	PC	Software purchase, PCs
	23	M	PC	PCs, SG subscriptions/purchases

Note. ^ = unpiloted interventions; FI = fully immersive; SI = semi-immersive; NI = non-immersive; H = high; M = moderate; L = low; PC = personal computer; SG = serious game; HMD = head-mounted device; N/A = not applicable. (Notes: in many of the studies, it was unclear which equipment was provided for students and which items they were expected to purchase.)

5.4.6. Inclusion in a learning program and learning theories

To better understand the learning approaches used in the reviewed studies, each article was examined for references to learning theories and for evidence of integration into a structured learning program (see Table 6). Thirteen articles described VR interventions that were incorporated into formal educational programs, a practice shown to make learning more meaningful and relevant (Merchant et al., 2014; van Ginkel et al., 2015). This approach aligns with best practices for designing extended reality (XR) learning experiences, as outlined by Karabina et al. (2023).

Across the reviewed literature, eight distinct learning theories were referenced. Two of these, constructivism (C) and experiential learning (EL), were introduced earlier in the paper. Additional theories included Social Cognitive Theory (SCT), which explains how learners acquire new skills through observation and imitation (Bandura, 1986), and Generational Theory (GT), which posits that different generational cohorts (e.g., Baby Boomers, Generation X, etc.) share common values, beliefs, and personality characteristics

(Lamm & Meeks, 2009). Hernandez-Pozas and Carreon-Flores (2019) applied this theory to suggest that each generation may require tailored educational approaches.

Gamification (G) was another frequently cited framework, involving the use of game elements such as points, badges, and leaderboards to motivate and engage learners (Narayan et al., 2013; Rohman & Fauziati, 2021). Closely related, the Serious Games (SG) approach integrates educational content and objectives into engaging gameplay to facilitate learning and skill development. Flow Theory (F) describes how a state of deep immersion and engagement can enhance motivation and learning outcomes (Csikszentmihalyi, 1994). Finally, Gibbs' Reflective Cycle (GRC) provides a structured framework for reflection (Gibbs, 1988).

Table 6 also categorizes the interventions by their design and purpose to contextualize the application of these learning theories. The twenty-three included articles were grouped into four categories: VR spaces for hosting curriculum and resources, metaverse-based spaces, immersive learning activities focused on developing a single skill set, and non-immersive serious games. This classification helps clarify how different pedagogical frameworks were applied across varying types of VR interventions. While some platforms may exhibit features of multiple categories, each intervention was classified based on its primary instructional intent and pedagogical structure. The following paragraphs define each category and provide examples from the reviewed literature.

'VR spaces for hosting curriculum and resources' refer to virtual environments designed primarily to deliver structured educational content. These platforms often simulate classrooms or learning hubs where students can access multimedia resources, interact with peers or instructors, and engage in guided learning activities. While some of these spaces may be immersive, their primary function is content delivery rather than experiential skill development. For example, the VR-ILM Smart Space (Pan, 2022) and the AGRIENT platform (Ionitescu et al., 2019a) fall into this category.

'Metaverse-based spaces' are persistent, shared virtual environments where users interact as avatars. These spaces often support open-ended exploration, social interaction, and user-generated content. Unlike VR learning platforms with fixed curricula, metaverse spaces such as Second Life (Peng & Abdullah, 2018) and the Indonesian Start-up Creative City (Novel & Alexandri, 2023) provide opportunities for informal learning through entrepreneurial activities, peer collaboration, and community engagement. While immersive, these environments are not necessarily designed for formal instruction but can support entrepreneurial mindset development through authentic experiences.

'Immersive learning activities developing a single skill set' are targeted VR interventions designed to build specific entrepreneurial competencies, such as negotiation, presentation, or ethical decision-making. These experiences are typically short-term, highly immersive, and structured around a particular learning objective. For instance, Ovation VR (McGovern et al., 2020) and the VR-based ethics learning experience (Sholihin et al., 2020) exemplify this category. These activities are distinct in their focused instructional design and limited scope.

'Non-immersive serious games' are digital games accessed via PCs or mobile devices that simulate entrepreneurial scenarios. These games are typically less immersive but offer high accessibility and cost-effectiveness. They often incorporate gamification elements and are well-suited for developing a broad range of entrepreneurial skills. Examples include ENTRExplorer (Almeida, 2017a, 2017b) and SimVenture (Williams,

2015), which allow learners to simulate business planning, decision-making, and management in a risk-free environment.

This categorization helps clarify the pedagogical intentions and technological affordances of each intervention, enabling a more nuanced analysis of their contributions to entrepreneurial skill development. Table 6 shows that interventions involving non-immersive serious games were well grounded in learning theory. These interventions commonly utilized experiential learning and gamification, a powerful combination. Several also incorporated reflective practices and promoted flow. Interventions in the other three categories cited fewer learning theories overall. However, several individual interventions also drew on multiple theoretical frameworks.

Table 6
Inclusion in a learning program and learning theories

Platform design and purpose	Article no.	Level of immersion (mode of access)	Formal learning program	Learning theory considered
VR spaces for hosting curriculum and resources	2	FI (PC)	Y	Non specified
	3	FI (PC)	Y	C, EL, G
	9	NI (Mobile)	Y	None specified
	10 [^]	FI (HMD)	N	None specified
	11 [^]	FI (PC)	N	None specified
	12 [^]	FI (Unspecified)	N	EL
	13 [^]	FI (Unspecified)	N	G
Metaverse-based interventions	14 [^]	FI (PC)	N	C, G
	1	FI (Unspecified)	N	EL
	5	FI (PC)	Y	C
	7	FI (PC)	N	EL
Immersive learning activities developing a single skill set	4	FI (HMD)	Y	EL, SCT, GT,
	6	FI (HMD)	Y	None specified
	8	FI (HMD)	Y	None specified
	15	SI (PC projected)	Y	EL, SG
	16	NI (PC)	Y	EL, SG, F
Non-immersive serious games	17	NI (PC)	Y	C, EL, G, F
	18	NI (PC)	Y	EL, G
	19	NI (PC)	Y	C, EL, G
	20	NI (PC)	Y	EL, SG
	21	NI (PC)	Y	EL, G, SG
	22	NI (PC)	Y	EL, G, SG, GRC
	23	NI (PC)	Y	G, SG

Note. [^] = unpiloted interventions; FI = fully immersive; SI = semi-immersive; NI = non-immersive; HMD = head-mounted device; PC = personal computer or laptop; PC projected = personal computer projected onto screens; Mobile = mobile device; SG = serious game; Y = yes; N = no; EL = experiential learning; SCT = social cognitive theory; G = gamification; GRC = Gibbs' reflective cycle; F = flow theory; C = constructivism

5.4.7. Skills developed

The articles identified various skills developed using VR, described with diverse language and terminology. To promote clarity and consistency, skills were assigned to the most appropriate EntreComp competency. Fig. 5 summarizes the EntreComp competencies developed in each article and groups interventions by their level of immersion. Competencies from unpiloted interventions are shown in light grey, while those from

piloted interventions are shown in bolder colours. Fig. 5 shows that serious games have successfully developed various competencies across all categories. Piloted fully immersive interventions have been less effective or underutilized in developing skills in the Ideas and Opportunities category. Unpiloted fully immersive interventions aim to develop these competencies, but follow-up research is needed to evaluate their effectiveness.

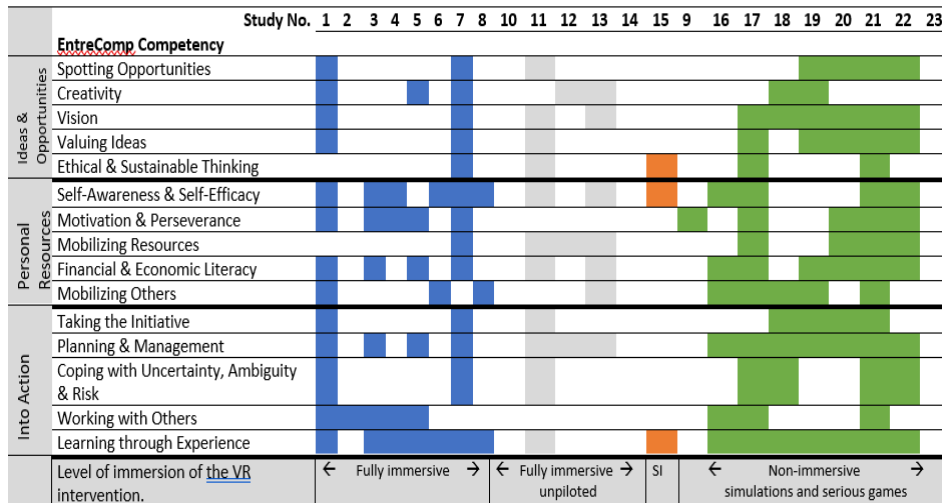


Fig. 5. EntreComp competencies developed by each VR learning experience (Competencies from unpiloted interventions are shown in light grey, and piloted interventions are shown in bolder colours)

Fig. 6 categorizes interventions by their design and purpose to clarify how these factors contribute to developing specific EntreComp competencies. The twenty-three included articles have been divided into the same four categories used in Table 6: VR spaces for hosting curriculum and resources, metaverse-based spaces, immersive learning activities developing a single skill set, and non-immersive serious games. As in Fig. 5, competencies from unpiloted interventions are shown in light grey, while those from piloted interventions are shown in bolder colours.

Fig. 6 shows that serious games and metaverse-based initiatives have successfully developed various competencies across all categories. Immersive learning activities designed to develop a single skill set have effectively developed competencies across all three categories. Piloted VR spaces for hosting curriculum and resources have been less effective or underutilized in developing skills in the Ideas and Opportunities category. VR spaces for hosting curriculum and resources aim to develop these competencies, but follow-up research is needed to evaluate their effectiveness.

Fig. 7 tallies the number of articles mentioning the development of each EntreComp competency. The five most frequently developed competencies were: Learning Through Experience, Planning and Management, Self-Awareness and Self-Efficacy, Motivation and Perseverance, and Financial and Economic Literacy. Ethical and Sustainable Thinking, along with Mobilizing Resources and Creativity, were the least frequently developed competencies.

Fig. 8 groups the skills into their associated EntreComp competency categories. Skills in the Into Action category were most frequently developed, followed by Personal Resources. Skills in the Ideas and Opportunities category were developed least frequently.

Study No.	2	3	9	10	11	12	13	14	1	5	7	4	6	8	15	16	17	18	19	20	21	22	23
EntreComp Competency																							
Ideas & Opportunities																							
Spotting Opportunities																							
Creativity																							
Vision																							
Valuing Ideas																							
Ethical & Sustainable Thinking																							
Personal Resources																							
Self-Awareness & Self-Efficacy																							
Motivation & Perseverance																							
Mobilizing Resources																							
Financial & Economic Literacy																							
Mobilizing Others																							
Into Action																							
Taking the Initiative																							
Planning & Management																							
Coping with Uncertainty, Ambiguity & Risk																							
Working with Others																							
Learning through Experience																							
Design and purpose of the VR intervention.	← VR Spaces for Hosting Curriculum & Resources →								Meta-verse			Single Skill Set				← Non-immersive Serious Games →							

Fig. 6. EntreComp competencies developed categorized by design and purpose of the VR intervention (competencies from unpiloted interventions are shown in light grey, and piloted interventions are shown in bold colours)

Fig. 9 explores the relationship between the level of immersion and the skills developed according to their EntreComp competency category. Skills in the Ideas and Opportunities category were less frequently developed than those in either the Into Action or Personal Resources categories. This trend was more pronounced for fully immersive VR interventions.

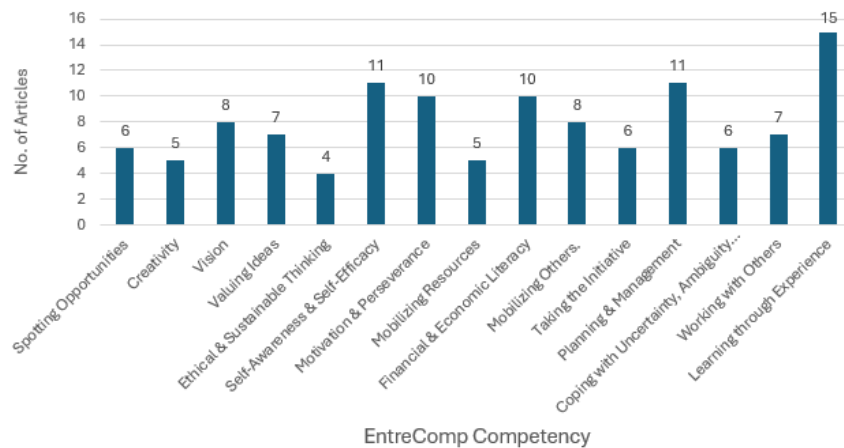


Fig. 7. Overall development of EntreComp competencies

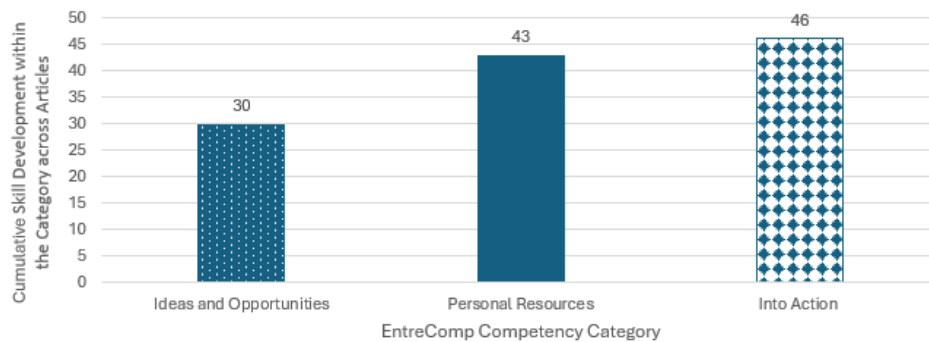


Fig. 8. Development of competencies within the EntreComp categories

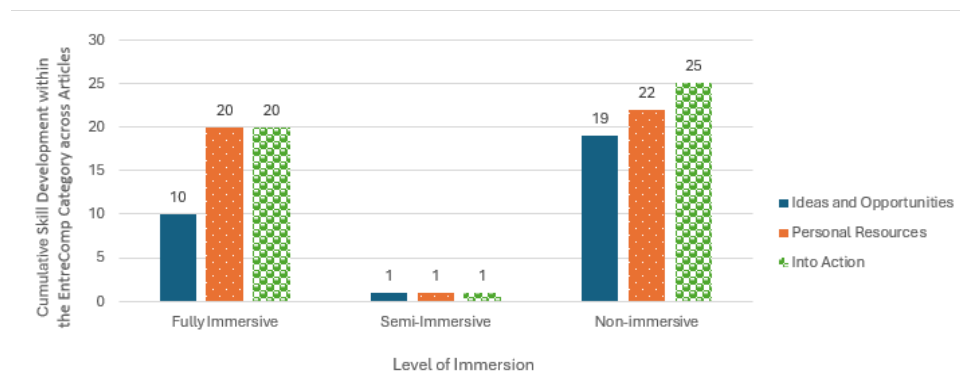


Fig. 9. Level of immersion and development of competencies in EntreComp categories

6. Discussions

This paper aims to answer three research questions, each of which will be addressed individually.

6.1. How have VR technologies been used to support entrepreneurial skill development (RQ1)?

In the included studies, four key factors were identified as contributing to learning and skill development through VR interventions. These factors are inclusion in a program of learning, instructor involvement, grounding in sound pedagogical principles, and alignment with intended learning outcomes. Each factor is discussed in the following paragraphs, with examples drawn from the reviewed literature.

Inclusion in a program of learning emerged as a foundational element. All but two of the piloted VR interventions were incorporated into a learning program (see Table 6), a practice that has been shown to make learning more meaningful for students (Merchant et al., 2014; van Ginkel et al., 2015). The two exceptions, Novel and Alexandri (2023) and Noke and Chesney (2014), focused on entrepreneurial skills developed through metaverse-based entrepreneurship. Their goal was to investigate virtual entrepreneurship for future learning. These studies are highly relevant as higher education continues to explore

alternate modes of learning to meet growing demands for “*more personalized, interactive, and purpose-driven learning experiences*” (Mintz, 2025).

Instructor involvement was another critical factor influencing the success of VR interventions. Instructors play a key role in developing and implementing VR learning experiences that are pedagogically sound (Radianti et al., 2020), aligned with intended learning outcomes (Bates, 2022), and well-integrated into a learning program (Merchant et al., 2014; van Ginkel et al., 2015b). Belotti et al. (2014) emphasized the essential role of instructors as they guide students in the “*fruitful use of such powerful tools*” and incorporate VR interventions into “*a meaningful educational path combining theory and practice*”. These examples underscore the importance of instructor facilitation in ensuring that VR activities are not only technically functional but also pedagogically effective.

Pedagogical alignment also significantly influenced the effectiveness of VR-based learning. Radianti et al. (2020) highlighted the need to align VR applications with sound pedagogical principles, cautioning that usability should not overshadow pedagogy. Table 6 outlines the learning theories referenced in each study and their connection to the design and purpose of the intervention. Seventeen of the included articles explicitly cited learning theories. Among those that did not, several still demonstrated pedagogical grounding. For example, two studies from China developed online platforms for interactive entrepreneurial learning: one fully immersive and accessed via PC (Pan, 2022), and the other non-immersive and accessed via mobile device (Zhang, 2023). Two additional studies focused on entrepreneurial pitch delivery using head-mounted displays (HMDs), showing equal or superior learning outcomes compared to alternate modes of practice (McGovern et al., 2020; van Ginkel et al., 2019). Although these studies did not explicitly reference experiential learning, their designs reflected Kolb’s (1984) four-stage experiential learning cycle. Furthermore, two unpiloted, fully immersive interventions aimed to create collaborative spaces for student interaction and engagement with educational resources, accessed via HMD (Li et al., 2022) and PC (Grivokostopoulou et al., 2020). Although these studies did not reference specific pedagogical frameworks, their design reflected constructivist principles by emphasizing learner interaction, social engagement, and access to contextualized content within immersive environments. Among the remaining studies, all eight that utilized non-immersive serious games incorporated both experiential learning and gamification, a combination shown to be particularly effective. Several also integrated reflective practices and promoted flow. While interventions in other categories referenced fewer learning theories, many were still pedagogically robust, combining experiential learning with gamification or other impactful learning theories.

Finally, learning outcomes were consistently prioritized across the design, selection, and assessment phases of VR learning interventions. In terms of design, Yang et al. (2022) emphasized the importance of ensuring that virtual simulation games align with course objectives. Similarly, Grivokostopoulou et al. (2019), Zhang (2023), and Buzady and Almeida (2019) highlighted how learning outcomes guided their course designs. During the selection process, Williams (2015) advised educators to establish goals and learning objectives when choosing and using games to facilitate learning. Antonaci et al. (2015) and Belotti et al. (2014) also described how prioritizing learning outcomes led them to select multiple games since “*no single game [was] able to meet all the ... criteria*”. Regarding assessment, Peng and Abdullah (2018) emphasized the importance of evaluating VR interventions against intended learning outcomes. Van Ginkel et al. (2019) guided students in setting individual learning outcomes that they later used to assess their own success, and

Pan (2022) reported increased student satisfaction with course learning outcomes following VR-based instruction. These examples illustrate how a consistent focus on learning outcomes enhances the pedagogical soundness of VR interventions.

Although artificial intelligence (AI) was not specifically included in the search string or research questions, two studies noted its use in enhancing learning in virtual worlds. With growing interest in AI for learning, further investigation into its role in VR-based learning is merited. Instructors using VR for entrepreneurship education should ensure that its design is grounded in sound pedagogy, aligned with intended learning outcomes, and integrated into a broader learning program. They should seek ongoing feedback from learners and use it to revise and refine the VR learning activity as needed to support the achievement of learning outcomes.

6.2. *What types of virtual reality have been used to develop entrepreneurial skills (RQ2)?*

6.2.1. *Level of immersion and mode of access*

Various levels of VR immersion have been used to develop entrepreneurial skills. Fully immersive VR was discussed in thirteen of the reviewed articles (see Table 4). Although this format tends to be more costly, it provides higher levels of mobility, interactivity, and presence and can be especially engaging and impactful when accessed using an HMD. Accessing fully immersive experiences via personal computers can reduce costs and mitigate issues such as cybersickness, while still offering moderate levels of mobility and interactivity. Additionally, avatar-based participation in fully immersive environments can foster a heightened sense of emotional safety, which is particularly beneficial for learners who experience anxiety or fear of failure (Hernandez-Pozas & Carreon-Flores, 2019; Noke & Chesney, 2014).

Semi-immersive VR was represented by a single intervention that involved projecting the virtual environment from a PC onto a screen. Although this approach offered limited portability, it provided enhanced immersion and interactivity. Sholihin et al. (2020) described how students were able to “*scan, rotate, and zoom the 3D model*”, demonstrating the potential for engaged and purposeful interaction.

Non-immersive VR interventions were described in nine studies, eight of which utilized serious games (SGs). These online platforms were accessible via PC or mobile device, making them more portable and less costly than more immersive interventions (see Table 5). Reduced cost, ease of access, and freedom from cybersickness make non-immersive VR the most accessible option for many learners. Serious games are well-established in entrepreneurship education globally. For instance, Kriz and Auchter (2016) documented fifteen years of successful implementation in Germany, while similar interventions have been conducted in Portugal (Buzady & Almeida, 2019), the United Kingdom (Williams, 2015), and across Italy, Spain, the Netherlands (Antonaci et al., 2015; Bellotti et al., 2014), as well as China (Yang et al., 2022). Given their accessibility, cost-effectiveness, and established global use, a more detailed examination of serious games was undertaken to assess game type, hosting location, mode of access, and implementation protocol (see Table 7).

Table 7

Serious games and simulations organized by game type and implementation

No.	Name	Hosting/access	Duration	Teams	Game type and implementation
16	Not specified	Online PC access	One term	External to game	Startup teams create a new company, develop new products to market, and compete with other teams.
17	FLIGBY	Cloud-based PC access	6 weeks	None	Individuals engage in role-play and scenario-based learning with personalized feedback to develop leadership competencies.
18	ENTRExplorer	Cloud-based PC access	Not specified	Not specified	Learners can simulate creating and running a new start-up. Different scenarios on eight building floors teach market and idea development, strategic positioning, product pricing and distribution, communication strategy, SWOT analysis, and financial viability.
19	ENTRExplorer	Cloud-based PC access	Not specified	Not specified	A strategic entrepreneurship simulation game focuses on startups and realistically simulates the stages of opening a business. Teams go through seven phases: team formation, information gathering, business planning, start-up, market entry/competition, success evaluation, and debriefing. This voluntary program is available to all students at German universities.
20	TOPSIM START-UP	Computer- based PC access	Not specified	Yes	
21	Hot Shot Business The Enterprise Game SimVenture MetaVals Slogan The Balance Sheet Team Up SimVenture	Various PC access	One term	Not specified	After reviewing and analysing the alignment of eight SGs with course outcomes, Italian, Spanish, and Dutch universities acknowledged that no single game could fully meet the outcomes, and selected combinations of 2 or 3 to use in each course. Learning was enhanced in each.
22	SimVenture	PC standalone PC access	10 sessions	External to game	After a term of preparatory learning, self-selected teams attended four tutor-guided introductory sessions, followed by a class discussion. Students then played individually for six sessions with class debriefings and reflective journaling.
23	Innov8 Team Up GoVentureSmallBusiness Industry Player MetaVals SimVenture Market Place Hot Shot Business The Balance Sheet Game The Enterprise Game	Various PC access	One term	Not specified	After reviewing ten SGs and their alignment with course outcomes, short descriptions of each game and preliminary results from course pilots in Italian, Spanish, and Dutch universities were discussed.

Bellotti et al. (2014) described serious games as “*powerful tools*” for entrepreneurial learning, enabling learners to tackle entrepreneurial problems, explore options, make decisions and experience consequences in low-risk environments. Learners receive immediate feedback, allowing them to quickly learn and adjust their strategies. These games support both individual and collaborative learning, are time- and location-

independent, and provide rich opportunities for applying classroom concepts through experiential learning. The effectiveness of serious games in these studies can be attributed not only to their interactive and experiential nature but also to thoughtful alignment with learning outcomes, guidance provided by instructors, and integration into structured educational programs.

6.2.2. Mobility, interactivity, portability, costs, and social features

In the articles reviewed, the highest levels of mobility and interactivity were associated with metaverse-based activities and virtual world environments. These included experiences such as starting and running businesses in the metaverse (Noke & Chesney, 2014; Novel & Alexandri, 2023), engaging in metaverse-based simulations (Peng & Abdullah, 2018) and participating in learning platforms where students could move freely and interact with virtual elements (Grivokostopoulou et al., 2019, 2020; Guan, 2020; Ionitescu et al., 2019a; Ionitescu et al., 2019b). Additionally, immersive environments designed for practicing presentation skills, such as those described by McGovern et al. (2020), demonstrated high levels of interactivity and presence.

Although metaverse-based entrepreneurship experiences supported the development of a wide range of entrepreneurial skills (see Fig. 6), they were not typically part of formal learning programs (see Table 6). Instead, these interventions focused on exploring the educational potential of virtual entrepreneurship and creating highly interactive spaces where entrepreneurs could collaborate and learn together. While many of these interventions were unpiloted, Grivokostopoulou et al. (2019) reported that their gamified approach successfully fostered six competencies within the Personal Resources and Into Action categories (see Fig. 6). These findings suggest that virtual worlds hold promise for entrepreneurship education, but further research is warranted to evaluate their educational efficacy.

McGovern et al. (2020) effectively used VR to enhance students' presentation skills, achieving superior outcomes compared to traditional instructional methods. Van Ginkel et al. (2019) reported similar learning gains using an intervention that offered less mobility and interactivity. However, they found their approach to be equally effective rather than superior. These findings suggest that future studies should investigate how varying levels of mobility and interactivity in fully immersive VR environments influence learning outcomes.

In general, VR activities with high mobility and interactivity also incorporated more social features (see Table 4), making them particularly suitable for fostering community among geographically dispersed learners. This was a common objective in virtual world-based entrepreneurship education (Grivokostopoulou et al., 2019; Grivokostopoulou et al., 2020; Guan, 2020; Ionitescu et al., 2019a; Ionitescu et al., 2019b). In contrast, McGovern et al. (2020) did not include social features in their intervention, as the primary goal was to improve individual pitch delivery skills. Including social features that are not aligned with learning objectives may distract learners and potentially hinder educational outcomes.

VR interventions with lower levels of mobility and interactivity and fewer social features (e.g., many of the reviewed serious games) have proven effective in developing a wide variety of entrepreneurial skills. Although the creation of high-quality serious games can be resource-intensive, many existing platforms are widely accessible and relatively low-cost. These interventions can be implemented quickly with minimal cost and are well-

suited for learners in diverse locations, making them an attractive option for entrepreneurship education. When selecting a VR learning intervention, instructors should ensure that the level of immersion, mode of access, mobility, interactivity, and social features align with learning outcomes and student needs, including needs related to portability, cost, accessibility, and social interaction. While higher levels of these elements can enhance learning and foster collaboration, they may also distract learners if not aligned with pedagogical principles and learning outcomes.

6.3. What entrepreneurial skills have been developed using virtual reality (RQ3)?

No single VR intervention developed all EntreComp competencies (see Fig. 5), but each competency was addressed by one or more intervention. To clarify how different interventions contribute to the development of specific competencies, the discussion has been organized to align with the four categories shown in Fig. 6. This structure provides a clear overview of how VR interventions support entrepreneurial skill development across diverse contexts.

6.3.1. VR spaces designed to host entrepreneurship curriculum and resources

Eight articles described VR spaces for hosting entrepreneurial resources, with skills developed varying according to the activities hosted. In the three piloted interventions, assessment focused on engagement, motivation, ease-of-use, and navigation. In addition, Pan (2022) reported improved teamwork; Grivokostopoulou et al. (2019) reported development of multiple skills in Personal Resources and Into Action categories; and Zhang (2023) reported improved motivation. In the five unpiloted platforms, Ionitescu et al. (2019b) and Li et al. (2022) did not discuss skill development, while Guan (2020), Grivokostopoulou et al. (2020), and Ionitescu et al. (2019a) proposed skill development across all EntreComp categories.

6.3.2. Metaverse-based interventions

Three articles described metaverse-based interventions. Noke and Chesney (2014) and Novel and Alexandri (2023) assessed informal learning among entrepreneurs running businesses in the metaverse, with Noke and Chesney (2014) focusing on novices and Novel and Alexandri (2023) on experienced entrepreneurs. Peng and Abdullah (2018) evaluated role-play activities in Second Life as part of a formal learning program. All three interventions supported skill development across the three EntreComp competency categories. The longer durations and robust experiential learning components in the first two studies contributed to more comprehensive skill development.

6.3.3. Immersive learning activities focusing on a single skill set

Four interventions focused on developing specific skills: Intercultural negotiation (Hernandez-Pozas & Carreon-Flores, 2019), business ethics (Sholihin et al., 2020), and presentation skills (McGovern et al., 2020; van Ginkel et al., 2019). VR was found to be equally effective (van Ginkel et al., 2019) or superior (McGovern et al., 2020) to other instructional methods. All interventions effectively developed the targeted skills (see Fig. 6).

6.3.4. *Non-immersive serious games*

Eight articles discussed using serious games (SGs) in entrepreneurship education. Concluding that no single serious game can develop every entrepreneurial skill (see Fig. 5), Antonaci et al. (2015) and Bellotti et al. (2014) designed courses that incorporated multiple serious games to ensure achievement of course outcomes (see Fig. 6). Based on their experience during pandemic shutdowns, Yang et al. (2022) highlighted key criteria for ensuring serious games effectively supported entrepreneurial skill development: providing students with a thorough introduction at the outset; ensuring alignment between the game and course learning outcomes; providing clear in-game feedback; incorporating sufficient levels of difficulty to challenge all students; and continuously monitoring individual and team interactions with instructor intervention when necessary.

6.3.5. *Skill assessment tools*

Assessment of entrepreneurial skill development across the twenty-three articles involved diverse tools and methods. The use of a single common tool could make future assessments more meaningful. Čopková et al. (2023) developed the EntreComp Questionnaire, a self-assessment tool for students. Future researchers should consider whether this tool meets the needs of their investigation. The development and adoption of a consistent assessment tool would benefit the field of entrepreneurship education. VR interventions have effectively supported skill development across all three EntreComp competency categories, particularly in Into Action and Personal Resources (see Fig. 8 and 9). Skills in the Ideas and Opportunities category, especially creativity, mobilizing resources, and ethical thinking, were less frequently developed (see Fig. 7). These gaps underscore the importance of using VR interventions to supplement, rather than replace, traditional entrepreneurial education programs (Karabina et al., 2023). While VR offers unique advantages in terms of engagement, interactivity, and accessibility, and can provide excellent opportunities for experiential learning, it is best combined with other modes of learning. Combining VR with traditional approaches can provide a balanced and effective educational experience, leveraging the strengths of both to maximize learning outcomes (Kozlinska et al., 2023).

7. Limitations

Due to the nature of the review process, this work has several limitations. First, the search was limited to Google Scholar, IEEE Xplore, and Scopus databases, which may have resulted in the exclusion of relevant studies; however, this constraint was necessary due to time limitations and reviewer capacity. Second, all articles were reviewed by a single investigator, which may have allowed biases to go unchecked. Third, the review focused on articles published between 2013 and 2024, based on the assumption that earlier studies would be less relevant due to the rapid evolution of VR technologies. Finally, only peer-reviewed journal articles were included. While this ensured a high-quality review, it may have led to the omission of insightful conference papers and book chapters, particularly given the emerging nature of VR and the time required for peer review. Despite these limitations, the review offers valuable insights, and in some cases, these constraints present opportunities for future research.

8. Conclusions and future research

This systematic literature review examined the use of virtual reality (VR) in entrepreneurship education between 2013 and 2024 to understand the types of VR being used, the skills being developed, and the efficacy of various VR technologies. Results indicate that non-immersive, semi-immersive, and fully immersive VR have been used to effectively develop entrepreneurial skills. Key factors supporting skill development include integration into a structured learning program, instructor involvement, grounding in sound pedagogical principles, and alignment with intended learning outcomes. These findings highlight the growing role of VR in entrepreneurship education and its potential to complement traditional teaching methods.

Higher levels of mobility, interactivity, and immersion can enhance learning, while social features may foster community and collaboration. However, these features may distract learners if not pedagogically aligned. Interventions with lower mobility and interaction, like serious games, are more affordable and accessible, yet still effective in developing entrepreneurial skills.

Overall, VR interventions have proven effective in supporting skill development across the EntreComp framework, particularly in the Into Action and Personal Resources categories. However, gaps remain in the Ideas and Opportunities category. Developing interventions that emphasize creativity, mobilizing resources, and ethical thinking could further advance the field and ensure a more balanced approach to entrepreneurial skill development.

When selecting VR interventions to enhance entrepreneurial learning, instructors must consider funding, learning outcomes, and student needs, including needs related to portability, cost, accessibility, and social interaction. Ongoing feedback should be sought from learners and revisions made as necessary to ensure that learning outcomes are achieved. While VR offers unique advantages in engagement, interactivity, and experiential learning, it is most effective when combined with other instructional methods. Instructors must find the right balance to meet the needs of their learners to optimize educational impact.

Future investigations could explore the use of the EntreComp Questionnaire as an assessment tool, the efficacy of virtual worlds, and the role of artificial intelligence in enhancing entrepreneurial skill development. In addition, researchers should consider longitudinal studies to assess the sustained impact of VR interventions on entrepreneurial skills over time. Such research would help educators make informed decisions about integrating VR and related technologies into entrepreneurship curricula.

Author Statement

The authors declare that there is no conflict of interest.

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