International Journal of Computer Information Systems and Industrial Management Applications
ISSN 2150-7988 Volume 18(19s) 2026 pp. 717-729
https://doi.org/10.70917/ijcisim-2026-5078
Article

Toward Lifelong and Life-wide Learning through a Sustainable Open Universal Learning (SOUL) Framework: A Systematic Review

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Abstract: Extended Reality (XR) represents a suite of immersive technologies encompassing Mixed Reality (MR), Virtual Reality (VR), and Augmented Reality (AR) that is fundamentally reshaping the landscape of business, training, education, and entertainment. The growing use of these technologies presents a compelling opportunity to promote sustainable education aligned with global agendas, including the United Nations Sustainable Development Goals (SDGs) and Education for Sustainable Development (ESD). Despite their potential, no established framework currently integrates immersive technology with the principles of sustainable and outcome-based education. This paper addresses that gap by proposing the Sustainable Open Universal Learning (SOUL) framework. A systematic review of 125 peer-reviewed articles published between 2013 and 2025, retrieved from the Scopus database, was conducted and supplemented with content analysis guided by predefined inclusion and exclusion criteria. The findings reveal that immersive technologies offer significant advantages in learner engagement, motivation, safety, and experiential learning across multiple educational levels and disciplines. The SOUL framework was structured around three value domains, namely Value Creation, Value Proposition, and Value Delivery, and integrates XR-based gamification and outcome-based education to deliver an open, universal, and sustainable learning environment. The framework aligns with SDGs 3, 4, 8, 9, 11, and 16, and contributes both theoretically and practically to the global discourse on technology-enhanced sustainable education.
Keywords: Extended Reality, Immersive Technologies, Sustainable Education, Outcome-Based Education

1. Introduction

Immersive technology has evolved from a niche novelty into a transformative force across multiple sectors. Historically, the concept of immersive experience was pioneered by Morton Heilig's Sensorama in 1962 [1], building on his seminal publication, “The Cinema of the Future” [2]. The first commercial Virtual Reality (VR) headset emerged eleven years later, and the field has since progressed to standalone, cable-free devices that no longer require a dedicated computer or console [3]. By 1992, the U.S. Air Force's deployment of Augmented Reality (AR) to enhance operator performance in remote environments signalled a paradigm shift, shifting immersive technologies from entertainment to applied, high-stakes domains [4]. Today, XR technologies encompassing AR, VR, Mixed Reality (MR), and Extended Reality (XR) as their main category are at the forefront of digital transformation in education, healthcare, manufacturing, and beyond.

Sustainable education has ascended to the top of global policy since the adoption of the United Nations Sustainable Development Goals (SDGs) in 2015 [5]. SDG 4, in particular, calls for equitable, inclusive, and quality education that promotes lifelong learning for all. This aspiration is further elaborated in UNESCO’s framework for Education for Sustainable Development (ESD), which defines sustainable education as a process that equips learners with the knowledge, skills, values, and attitudes necessary for a sustainable future [6][7]. Complementarily, the OECD

Learning Framework 2030 advocates for holistic learner well-being and diverse competencies as prerequisites for transforming societies [8][9].

Despite the growing body of research on immersive educational technology and the urgency of sustainable education agendas, a critical gap persists. There is a lack of an existing framework that integrates XR-based platforms with the full spectrum of sustainable education principles, including ESD, SDG alignment, and outcome-based learning, see Fig 1. Prior frameworks for immersive education [10][11] primarily focus on cognitive and motivational outcomes in virtual environments, without systematically addressing sustainability dimensions. This study addresses that lacuna by proposing the Sustainable Open Universal Learning (SOUL) framework, grounded in a systematic review of the literature on immersive technologies and sustainable education.

Fig. 1. Research gaps

The research objectives guiding this study are: (1) to identify the key elements of an immersive technology platform capable of delivering sustainable education; and (2) to determine the critical enablers for ESD's thematic focus areas toward a sustainable future.

2. Literature Review

A. Immersive Technologies in Education

The integration of immersive technologies, particularly VR and AR, into education has attracted sustained scholarly attention over the past decade. Meta-analyses and systematic reviews consistently report positive effects on learner engagement, motivation, and cognitive performance [12][13][14]. VR enables the creation of simulated environments that replicate real-world conditions, thereby offering experiential learning opportunities that would otherwise be inaccessible, unsafe, or cost-prohibitive [15][16]. AR overlays digital content onto the physical environment, enriching learning without requiring full environmental substitution [17][18].

However, research also cautions against an uncritical adoption of immersion. Makransky et al. (2019) demonstrated that adding immersive VR to a science simulation increased learners' sense of presence but unexpectedly reduced learning outcomes, a finding attributed to extraneous cognitive load induced by the richness of the virtual environment [14]. Parong and Mayer (2018) corroborated this, showing that immersive VR performed no better than desktop slideshows in promoting factual science learning [19]. These findings underscore the need for theoretically informed instructional design when deploying XR tools, a core design principle embedded in the SOUL framework.

B. Sustainable Education and Global Frameworks

Sustainable education, as conceptualised by Jeronen [20] and anchored in UNESCO's ESD framework, transcends environmental literacy to encompass transformative learning that nurtures systems thinking, future orientation, and civic agency. The OECD Learning Framework 2030 articulates competencies for sustainable futures, including knowledge, skills, values, and attitudes that closely mirror ESD objectives [8]. Outcome-Based Education (OBE), introduced by Spady (1994), provides a pedagogical framework that foregrounds measurable attainment of competencies over input-centric curricula [21], aligning naturally with both SDG 4 and ESD principles.

Despite this conceptual collaboration, empirical examinations of frameworks that operationally integrate XR with ESD remain limited. Existing immersive education frameworks, such as the M-iVR-L framework [11], the Cyber-Human Learning Framework [22], and the Educational Framework for Immersive Learning [10][23], focus primarily on cognitive and affective learning outcomes in virtual environments and do not address sustainability dimensions or SDG alignment. The SOUL framework is positioned to bridge this gap.

3. Methodology

This study adopts a two-phase research design: a systematic literature review (SLR) followed by content analysis, consistent with established protocols for evidence synthesis in educational technology research [24]. The methodological process is structured according to the IMRAD convention, and the SLR reporting adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [25]. Fig 2 illustrates the literature review, content analysis, and framework development process, as well as the IMRAD and conclusion.

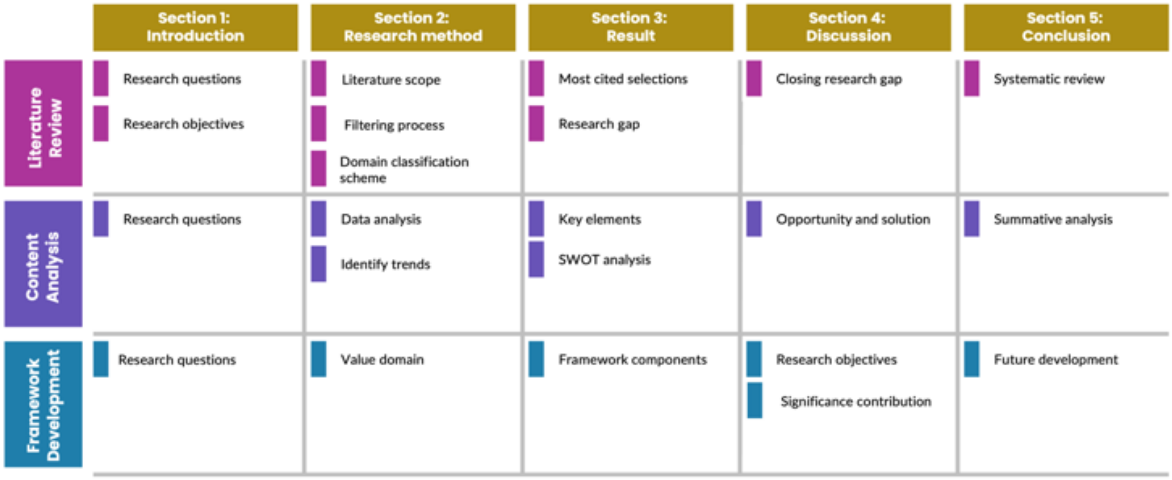

Fig. 2. The research process is outlined based on the structure of this paper.

A. Search Strategy and Database

The Scopus database was selected as the primary source due to its comprehensive coverage of peer-reviewed literature in science, technology, and social sciences. The search was conducted using the Boolean query: TITLE-ABS-KEY ("immersive" AND "sustainable education"). Additional grey literature and official reports from intergovernmental organisations including the United Nations, UNESCO, and the OECD were included to capture policy-relevant evidence.

B. Inclusion and Exclusion Criteria

Studies were included if they: (a) focused on the application or evaluation of immersive technologies in educational contexts; (b) addressed sustainability in education or outcomes aligned with ESD or SDGs; (c) were published between 2013 and 2025; (d) were published in English; and (e) were available as full-text, indexed publications. Studies were excluded if they: (a) focused exclusively on immersive technology applications in

entertainment or non-educational business processes; (b) were published in languages other than English; or (c) did not provide sufficient empirical or conceptual evidence relevant to the research questions.

C. Screening and Selection Process

An initial search yielded 125 articles after deduplication and year-range filtering. Following title, keyword, and abstract screening, articles were classified into three research domains (see Table I). Sub-domains were derived from keyword clustering across the 125 retrieved articles. Full-text content analysis was subsequently applied to all 125 articles, resulting in the exclusion of 13 articles that did not sufficiently address both immersive technology and sustainability in education. The final corpus comprised 112 articles. Table II maps the research questions to the corresponding steps in the research process.

TABLE I
Research Domains and Sub-Topics in the Systematic Review

Research Domain	Sub-domain
Sustainable Technology (Immersive Technology)	Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and Extended Reality (XR)
Sustainable Education	Education for Sustainable Development (ESD), competencies, knowledge, skills, values, attitudes, outcome-based education
Immersive Education Framework	Immersive technology framework, immersive reality framework, XR-based pedagogical models

TABLE II
Mapping of Research Questions to the Research Process

Research Questions	Research Process
Research Question 1: What are the main elements that can be considered in delivering sustainable education using immersive technologies?	Year filtering (2013–2025), title/abstract/full-text screening, domain classification, content analysis (trend identification and element extraction)
Research Question 2: What is the key enabler for ESD's thematic focus areas toward a sustainable future?	Title/abstract/full-text screening, domain classification, content analysis (opportunity analysis aligned with UNESCO Education for Sustainable Development roadmap)

4. Results

Following full-text content analysis, 112 articles were retained for synthesis. The results are presented in two subsections: the most-cited articles on immersive technologies for learning, and existing immersive education frameworks identified in the literature.

A. Most Cited Articles on Immersive Technologies for Learning

Table III presents the ten most-cited Scopus-indexed articles on immersive technologies for learning identified in the reviewed corpus. These articles represent the most influential empirical and review contributions to the field and are foundational to the development of the SOUL framework. Citation counts reflect Scopus data as of the search date (2025).

TABLE III
Most Cited Articles on Immersive Technologies for Learning

Author(s)	Article Title	Year	Research Gap(s) Identified	Cited by
Rojas-Sánchez, M.A., Palos-Sánchez, P.R., & Folgado-Fernández, J.A.	Systematic literature review and bibliometric analysis on virtual reality and education	2023	Need for stronger pedagogy-driven VR designs; more longitudinal and cross-country empirical evidence	809
Radianti, J., Majchrzak, T.A., Fromm, J., & Wohlgenannt, I.	A systematic review of immersive VR applications for higher education: Design elements, lessons learned, and research agenda	2020	Insufficient linkage between VR design elements, learning content, and educational theory	592
Jensen, L., & Konradsen, F.	A review of the use of virtual reality head-mounted displays in education and training	2018	Limited evidence on HMD-based VR for transferable skills acquisition across diverse disciplines	454
Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V.M., & Jovanović, K.	Virtual laboratories for education in science, technology, and engineering: A review	2016	Need for multidisciplinary virtual labs promoting constructive and collaborative learning	437
Makransky, G., Terkildsen, T.S., & Mayer, R.E.	Adding immersive virtual reality to a science lab simulation causes more presence but less learning	2019	Extraneous cognitive load in immersive environments undermines learning; need for instructional design to mitigate this	430
Moro, C., Štromberga, Z., Raikos, A., & Stirling, A.	The effectiveness of virtual and augmented reality in health sciences and medical anatomy	2017	Comparative impacts of VR, AR, and tablet-based applications on anatomy learning outcomes require further investigation	371
Sacks, R., Perlman, A., & Barak, R.	Construction safety training using immersive virtual reality	2013	Hypothesis testing in VR-based safety training at construction sites is nascent; scalability and transfer to real-world behavior untested	342

Parong, J., & Mayer, R.E.	Learning science in immersive virtual reality	2018	Immersive VR did not outperform desktop presentations; instructional design principles for XR need theoretical grounding	316
Lindgren, R., & Johnson-Glenberg, M.	Emboldened by Embodiment: Six Precepts for Research on Embodied Learning and Mixed Reality	2013	Learning technologies should prioritize embodied performance measurement; theoretical frameworks for MR remain under-developed	290
Barsom, E.Z., Graafland, M., & Schijven, M.P.	Systematic review on the effectiveness of augmented reality applications in medical training	2016	AR applications in medical professionals' education are promising but lack rigorous experimental designs	280

B. Existing Immersive Education Frameworks

Table IV synthesises the key immersive education frameworks identified in the literature. Analysis of these frameworks reveals a consistent focus on cognitive and motivational outcomes, but a notable absence of sustainability dimensions, SDG alignment, or life-wide and lifelong learning principles. This gap directly motivates the development of the SOUL framework.

TABLE IV
Existing Immersive Education Frameworks Identified in the Literature

Author(s)	**Framework Title**	**Year**	**Description and Application**
Dengel, A., & Maegdefrau, J.	Educational Framework for Immersive Learning	2018	Describes motivational, cognitive, and emotional influence factors; considers learning activities inside and outside virtual environments including teacher, family, context, and instructional variables
Gupta, A., Cecil, J., Tapia, O., & Sweet-Darter, M.	Cyber-Human Learning Framework	2019	Develops VR training environments by integrating cyber-human and human-computer interaction principles, haptics, and an information-centric

			systems engineering approach
Mulders, M., Buchner, J., & Kerres, M.	Meaningful IVR Learning (M-iVR-L) Framework	2020	Delivers meaningful learning via constructive interactions, immersive guidelines, tasks, and learning resources tied to defined outcomes
Dengel, A., & Maegdefrau, J.	Educational Framework for Immersive Learning (updated)	2020	Extended model incorporating motivation, cognition, emotion, learning outcomes, perception, interpretation, and instructional medium
Herodotou, C.	MAD Learn	2021	Evidence-based affordance framework integrating game and learning elements: activity, instruction, task, and reward structures
Johnson, E. K.	ELLE-meets Framework	2021	University-level VR game framework enabling player-game communication via aesthetics, calls-to-action, and explanation categories
Cecotti, H., & Callaghan, M.	Learning Mechanics–Game Mechanics (LM-GM) Framework	2021	Maps learning pedagogy and outcomes to serious game mechanics for VR-based learning environments
Barbe, H., Muller, J.L., & Fromberger, P.	Information Flow of VR-Training Framework	2022	Web-based VR training using speech-to-text interaction with virtual characters, real-time feedback, and embedded questionnaires

5. Discussion

A. Immersive Technologies as Enablers of Sustainable Education

The systematic review confirms that VR and AR technologies have significant potential to enable sustainable education. Across 112 reviewed articles, improvements in learner motivation, engagement, and experiential knowledge acquisition were consistently reported across diverse domains, including health sciences [17][18], engineering [16][26], and general STEM education [14][15]. Higher education institutions and industry leaders alike have embraced XR for training and professional development [15][27][28], signalling a convergence of educational and economic sustainability goals.

A key finding is the alignment between Outcome-Based Education (OBE) and the competency-focused objectives of ESD. Spady (1994) argued that OBE should provide broad learning opportunities, recognise lifelong achievement, and validate diverse learning outcomes principles that resonate with UNESCO's ESD competencies and

the OECD's Learning Framework 2030 [8][29]. Gamification, through its reward and badge mechanics, operationalises these OBE principles by providing visible, validated recognition of competency attainment, thereby enhancing motivation and enabling personalised learning trajectories [30] [31].

B. The SOUL Framework

The SOUL (Sustainable Open Universal Learning) framework (Fig 3) was developed as a synthesis of the systematic review's findings, the gaps identified in existing immersive education frameworks (Table IV), and the requirements of international sustainable education agendas. The framework is structured around three interconnected value domains derived from shared value theory [32]: Value Creation, Value Proposition, and Value Delivery. These domains are described in detail in Table V.

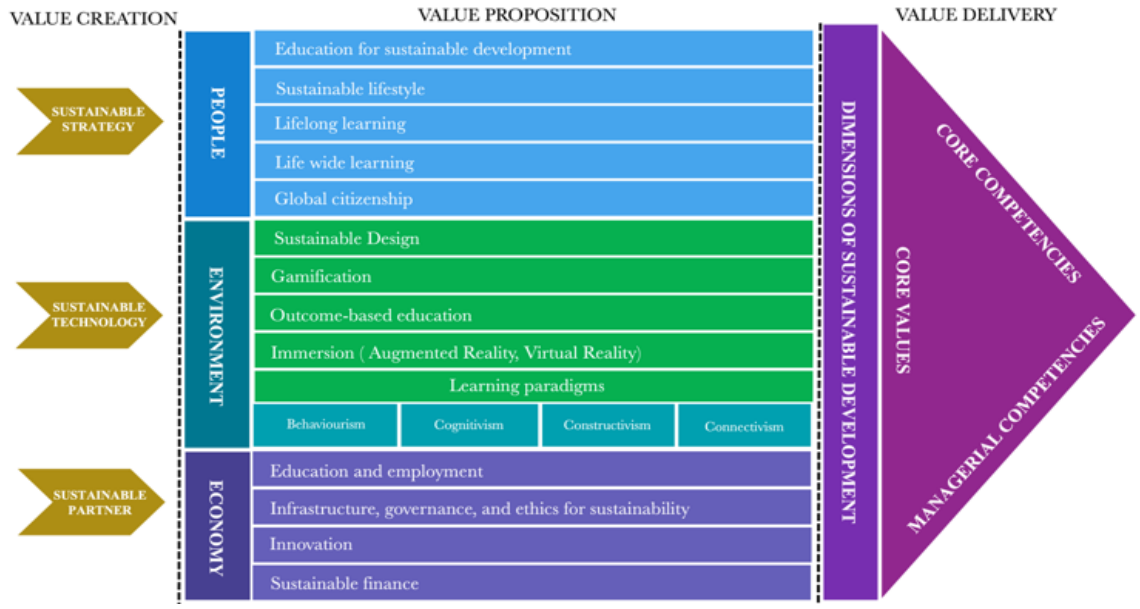

Fig. 3. Sustainable Open and Universal Learning (SOUL) framework.

The Value Creation domain establishes the foundational strategic, technological, and partnership conditions for sustainable immersive education. Specifically, it requires learning objectives to be aligned with SDGs and national/global education agendas, technology to be selected for its capacity to reduce resource consumption and carbon production through digital simulation [5][33], and global partnerships to be cultivated to enable collective knowledge creation [5] [9].

The Value Proposition domain addresses the people, environment, and economy dimensions of sustainability. For people, the framework operationalises the four UNESCO education pillars (learning to know, do, be, and live together) through cognitivist, behaviourist, affective, and volitional learning modalities [8][29]. For the environment, the framework integrates sustainable design principles, gamification, OBE, and AR/VR immersion to create a learning environment that exposes learners to real-world sustainability challenges and promotes critical thinking. For the economy, the framework aligns with digital skills development, labour market readiness, and sustainable infrastructure governance [34][35].

The Value Delivery domain articulates the intended outcomes: sustainability competencies (knowledge, skills, experiences, attitudes, and values), core values (integrity, diversity ethics, professionalism, and commitment), and managerial competencies (strategic thinking, decision-making, and global partnership skills), all of which reflect the attributes of a sustainable global citizen [36].

TABLE V
Descriptions and References for the SOUL Framework Components

Value Domain	Component	Description
Value Creation	Strategy	Learning objectives linked to SDGs, national and global education agendas, incorporating transformative pedagogy and structural change toward technological futures [7] [8] [33] [34] [35] [36].
	Sustainable Technology	Technology reduces resource consumption and carbon production through digital objects and virtual interactions; promotes sustainability values and citizenship in action[5] [33] [35].
	Sustainable Partnership	Delivers shared value and sustainable vision through global partnerships; collective creation of new knowledge for all [5][9][33][34][36].
Value Proposition (People)	Competencies	Four education pillars (learn to know, do, be, live together) promoting cognitive, behavioral, affective, and volitional learning[8] [9] [7] [29][35][36][37].
	Sustainable Lifestyle	Fosters wellness, well-being, and access to diverse cultural resources for sustainable community development [33] [34] [35].
	Lifelong Learning	Extends learning beyond formal education to address current and future labor market needs [7] [34] [35].
	Life-wide Learning	Educational innovation providing access to diverse cultural resources and real-world sustainability contexts [35].
	Global Citizenship	Motivates learners to explore alternative values; promotes citizenship in action and socio-emotional competencies [33] [34] [36].
Value Proposition (Environment)	Sustainable Design	Learning environment design aligned with sustainable development; promotes safe, reusable, and socially transformative learning [7] [33].
	Gamification	Badges and rewards recognize and validate knowledge, experiences, achievements, and competency reflections [35].
	Outcome-Based Education	Learning environment promotes competency-focused outcomes over competitive academic grading, supporting learner motivation[7] [29] [34] [35] .
	Immersion (AR/VR)	Provides comprehensive, diverse learning environments exposing learners to real-world sustainability problems; promotes critical thinking [33][38].
	Learning Paradigms	Promotes cognitivism, behaviourism, constructivism, and connectivism as learning objectives for SDGs[36].

Value Proposition (Economy)	Education and Employment	Extends lifelong learning to foster knowledge and skills acquisition for current and future labour markets[33] [34] [35].
	Infrastructure, Governance, and Ethics	Resilient management integrity strengthening education and providing universal access to safe, inclusive learning[5] [34]
	Innovation	Affordable educational technology advancements promoting sustainability values and transformative pedagogical encounters[9] [29] [33] [34] [39].
	Sustainable Finance	Investments supporting environmental goals, SDGs, and Green Deals; ensuring long-term sustainable economic growth [33] [35][40].
Value Delivery	Sustainability Dimensions	Triple bottom line outcomes (society, environment, economy) delivering shared values and prosperity [5] [7] [9] [33].
	Core Competencies	Sustainable citizenship: knowledge, skills, experiences, attitudes, and values cultivated through OBE and ESD [8] [9] [7] [29] [36] [37].
	Core Values	Integrity, diversity ethics, professionalism, and commitment toward sustainability [37] [41].
	Managerial Competencies	Strategic thinking, quality decision-making, and global partnership skills; technology management and sustainability leadership [37][41].

C. SOUL Framework Contributions to the Sustainable Development Goals

Table VI summarises the SOUL framework's contributions to six directly relevant SDGs, demonstrating the framework's capacity to operationalise global sustainability commitments at the level of educational practice.

TABLE VI
SOUL Framework Contributions to the Sustainable Development Goals

Sustainable Development Goal	**SOUL Framework Contribution**
SDG 3: Good Health and Well-Being	Learner-centred flexibility reduces learning-induced stress and anxiety. Broader community support promotes holistic well-being.
SDG 4: Quality Education	Access to diverse, current, and relevant learning content through immersive XR environments; promotes equity in educational opportunity.
SDG 8: Decent Work and Economic Growth	Lifelong and life-wide learning enhances employability and labour market participation in the digital economy.
SDG 9: Industry, Innovation, and Infrastructure	Fosters sustainable educational technology and infrastructure; nurtures sustainability values and digital innovation capacity.
SDG 11: Sustainable Cities and Communities	Promotes socio-emotional learning, global citizenship, and equitable access to educational services for sustainable communities.

SDG 16: Peace, Justice, and Strong Institutions	Universal access to quality education fosters inclusion, participation, and civic accountability through open learning environments.

6. Conclusions

This study contributes to the growing body of literature on educational technology and sustainable development by proposing the Sustainable Open Universal Learning (SOUL) framework. The framework is grounded in a systematic review of 112 Scopus-indexed articles (2013–2025). It addresses a clearly identified gap in the literature: no existing immersive education framework integrates XR-based platforms with the full spectrum of sustainable education principles, including ESD, SDG alignment, and outcome-based learning.

The SOUL framework's three value domains: Value Creation, Value Proposition, and Value Delivery provide a comprehensive, theoretically grounded structure for deploying immersive technologies in sustainable education. The framework demonstrates direct alignment with SDGs 3, 4, 8, 9, 11, and 16, as well as UNESCO's ESD thematic focus areas [7]. Table VII summarises how the SOUL framework addresses the research questions.

TABLE VII
SOUL Framework responses to the Research Questions

Research Question	SOUL Framework Response
RQ1: What are the main elements that can be considered in delivering sustainable education using immersive technologies?	Value Creation (strategy, sustainable technology, sustainable partnership), Value Proposition (competencies, sustainable lifestyle, lifelong/life-wide learning, global citizenship, sustainable design, gamification, OBE, immersion, learning paradigms, education/employment, infrastructure/governance, innovation, sustainable finance), and Value Delivery (sustainability dimensions, core competencies, core values, managerial competencies)
RQ2: What are the key enablers for ESD's thematic focus areas toward a sustainable future?	Immersive virtual reality (VR), gamification, augmented reality (AR), and diverse/life-wide learning experiences are identified as the critical enablers for operationalizing ESD thematic areas

The SOUL framework also directly addresses the OECD Education 2030 challenges: time constraints for competency development, work-life balance, outdated curricula, content quality, and equity in access to educational technology [8]. By proposing a flexible, gamified, XR-enabled platform grounded in OBE and ESD, the framework offers a theoretically coherent and practically actionable response to these systemic challenges in contemporary education.

Several limitations should be acknowledged. First, the systematic review was restricted to the Scopus database, which, while comprehensive, may have excluded relevant grey literature or conference proceedings indexed only in other databases (e.g., Web of Science, ERIC). Second, the SOUL framework is currently a theoretical proposal; its efficacy and usability have not yet been empirically validated. Third, the citation counts reported in Table III reflect Scopus data as of 2025 and are subject to change.

Future research should focus on: (1) empirical validation of the SOUL framework through expert evaluation, user testing, and pilot implementation in higher education institutions across diverse cultural and geographical contexts; (2) integration of emerging technologies, including Artificial Intelligence (AI), machine learning, and big data analytics, to enrich personalized learning experiences within the SOUL platform; (3) longitudinal assessment of learner outcomes, competency attainment, and sustainability behavioral change attributable to SOUL-based interventions; and (4) cross-national comparative studies to examine the framework's adaptability across varying educational, regulatory, and infrastructure contexts.

REFERENCES

1. H. Brockwell, “Forgotten genius: The man who made a working VR machine in 1957.” Techradar. 2016. [Online]. Available: https://www.techradar.com/news/wearables/forgotten-genius-the-man-who-made-a-working-vr-machine-in-1957-1318253
2. M. Heilig, “The cinema of the future. Espacios 38, 4 (1955).” [Reprinted 2014]. 1955. [Online]. Available: https://gametechdms.files.wordpress.com/2014/08/w6_thecinemaoffuture_morton.pdf
3. Techradar. 2023. The best VR headsets in 2023. [Online]. Available: https://www.techradar.com/news/the-best-vr-headset
4. L. Rosenberg, “Augmented reality: Reflections at thirty years.” Proceedings of the Future Technologies Conference (FTC) 2021. Vancouver, Canada. 2021. [Online]. Available: https://www.researchgate.net/publication/353753442
5. United Nations. “The post-2015 development agenda. “United Nations Sustainable Development Summit 2015. New York.
6. UNESCO. “Shaping the future we want: UN Decade of Education for Sustainable Development (2005–2014).” UNESCO, Paris, France. 2014.
7. UNESCO. “Education for Sustainable Development: A roadmap (2nd ed.)." UNESCO, Paris, France. 2022.
8. OECD. “The future of education and skills: Education 2030.” Organisation for Economic Co-operation and Development. 2018. [Online]. Available: https://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf
9. OECD. “Learning Compass 2030. Organisation for Economic Co-operation and Development.” 2019. [Online]. Available: https://www.oecd.org/education/2030-project/contact/OECD_Learning_Compass_2030_Concept_Note_Series.pdf
10. A. Dengel, and J. Maegdefrau, “Immersive learning explored: Subjective and objective factors influencing learning outcomes in immersive educational virtual environments.” Proceedings of the 2018 IEEE 7th International Conference on Teaching, Assessment, and Learning for Engineering (TALE). Wollongong, Australia. 2018.
11. M. Mulders, J. Buchner, and M. Kerres, “A framework for the use of immersive virtual reality in learning environments.” International Journal of Emerging Technology in Learning, vol. 15, 24 (2020), pp. 208–224. 2020.
12. Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., and Davis, T. J. 2014. Effectiveness of virtual reality-based instruction on students’ learning outcomes in K-12 and higher education: A meta-analysis. Computers & Education 70 (2014), 29–40. https://doi.org/10.1016/j.compedu.2013.07.033
13. Radianti, J., Majchrzak, T. A., Fromm, J., and Wohlgenannt, I. 2020. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Computers & Education 147 (2020), 103778. https://doi.org/10.1016/j.compedu.2019.103778
14. Makransky, G., Terkildsen, T. S., and Mayer, R. E. 2019. Adding immersive virtual reality to a science lab simulation causes more presence but less learning. Learning and Instruction 60 (2019), 225–236. https://doi.org/10.1016/j.learninstruc.2017.12.007
15. Jensen, L. and Konradsen, F. 2018. A review of the use of virtual reality head-mounted displays in education and training. Education and Information Technologies 23, 4 (2018), 1515–1529. https://doi.org/10.1007/s10639-017-9676-0
16. Potkonjak, V., Gardner, M., Callaghan, V., Mattila, P., Guetl, C., Petrović, V. M., and Jovanović, K. 2016. Virtual laboratories for education in science, technology, and engineering: A review. Computers & Education 95 (2016), 309–327. https://doi.org/10.1016/j.compedu.2016.02.002
17. Barsom, E. Z., Graafland, M., and Schijven, M. P. 2016. Systematic review on the effectiveness of augmented reality applications in medical training. Surgical Endoscopy 30, 10 (2016), 4174–4183. https://doi.org/10.1007/s00464-016-4800-6
18. Moro, C., Štromberga, Z., Raikos, A., and Stirling, A. 2017. The effectiveness of virtual and augmented reality in health sciences and medical anatomy. Anatomical Sciences Education 10, 6 (2017), 549–559. https://doi.org/10.1002/ase.1696
19. Parong, J. and Mayer, R. E. 2018. Learning science in immersive virtual reality. Journal of Educational Psychology 110, 6 (2018), 785–797. https://doi.org/10.1037/edu0000241
20. Jeronen, E. 2022. Sustainable education. In S. Idowu et al. (Eds.), Encyclopedia of Sustainable Management. Springer, 1–10. https://doi.org/10.1007/978-3-030-02006-4_237-1
21. Spady, W. G. 1994. Outcome-based education: Critical issues and answers. American Association of School Administrators. [Online]. Available: https://files.eric.ed.gov/fulltext/ED380910.pdf
22. Gupta, A., Cecil, J., Tapia, O., and Sweet-Darter, M. 2019. Design of cyber-human frameworks for immersive learning. In Proceedings of the 2019 IEEE International Conference on Systems, Man and Cybernetics (SMC). Bari, Italy, 1563–1568. https://doi.org/10.1109/SMC.2019.8914205
23. Dengel, A. and Maegdefrau, J. 2020. Immersive learning predicted: Presence, prior knowledge, and school performance influence learning outcomes in immersive educational virtual environments. In Proceedings of the 2020 6th International Conference of the Immersive Learning Research Network (iLRN), 163–170. https://doi.org/10.23919/iLRN47897.2020.9155084
24. Costa, A. C. F., Santos, V. H. M., and Oliveira, O. J. 2021. Towards the revolution and democratisation of education: A framework to overcome challenges and explore opportunities through Industry 4.0. Informatics in Education 21, 1 (2021), 1–32.

25. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., and PRISMA Group. 2009. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLOS Medicine 6, 7 (2009), e1000097. https://doi.org/10.1371/journal.pmed.1000097
26. Sacks, R., Perlman, A., and Barak, R. 2013. Construction safety training using immersive virtual reality. Construction Management and Economics 31, 9 (2013), 1005–1017.
27. BMW. 2021. BMW Sustainability Report 2021. BMW Brilliance Automotive Ltd. [Online]. Available: http://www.bmw-brilliance.cn/cn/en/common/download/sustainability_report/BBA_SR_2021_Full_Report_EN_FINAL.pdf
28. Bank of America. 2021. Bank of America is first in industry to launch virtual reality training program in nearly 4,300 financial centers. [Online]. Available: https://newsroom.bankofamerica.com/content/newsroom/press-releases/2021/10/bank-of-america-is-first-in-industry-to-launch-virtual-reality-t.html
29. UNESCO. 2012. Learning for the future: Competencies in education for sustainable development. UNESCO, Paris, France.
30. Crawford, C. 2018. Learnification: Encouraging learning through video games. In The Blue Dot: Exploring new ideas for a shared future, Issue 8. UNESCO MGIEP.
31. Koivisto, J. and Hamari, J. 2014. Demographic differences in perceived benefits from gamification. Computers in Human Behavior 35 (2014), 179–188.
32. Balian, A. and Ghevondyan, A. 2018. Creating shared value. Open Journal for Sociological Studies 2, 1 (2018), 37–46.
33. UNESCO. 2020. Education for Sustainable Development: A roadmap. UNESCO, Paris, France
34. UNESCO. 2015. Education 2030 Framework for Action. UNESCO, Paris, France.
35. UNESCO. 2021. Reimagining our futures together: A new social contract for education. UNESCO, Paris, France.
36. UNESCO. 2017. Education for Sustainable Development: Learning Objectives. UNESCO, Paris, France.
37. UNESCO. 2016. UNESCO Competency Framework. UNESCO, Paris, France.
38. UNESCO MGIEP. 2018. The Blue Dot: Exploring new ideas for a shared future, Issue 8. UNESCO Mahatma Gandhi Institute of Education for Peace and Sustainable Development, New Delhi, India.
39. UNESCO. 2022. Education for Sustainable Development: A roadmap (2nd ed.). UNESCO, Paris, France.
40. European Commission. 2021. Strategy for financing the transition to a sustainable economy. [Online]. Available: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021DC0390
41. United Nations. 2010. UN Competency Development: A Practical Guide. United Nations. [Online]. Available: https://hr.un.org/sites/hr.un.org/files/Un_competency_development_guide.pdf.