

Exploring Metaverse-Enhanced Learning: Learning Design Practices in K-12 Education

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Research Questions

Our study addresses two primary research questions:

- (1) What are the current goals and learning design practices in using metaverse technology in K-12 education?*
- (2) What opportunities and barriers are inherent to the adoption of metaverse technology in K-12 education?*

Searching the Literature

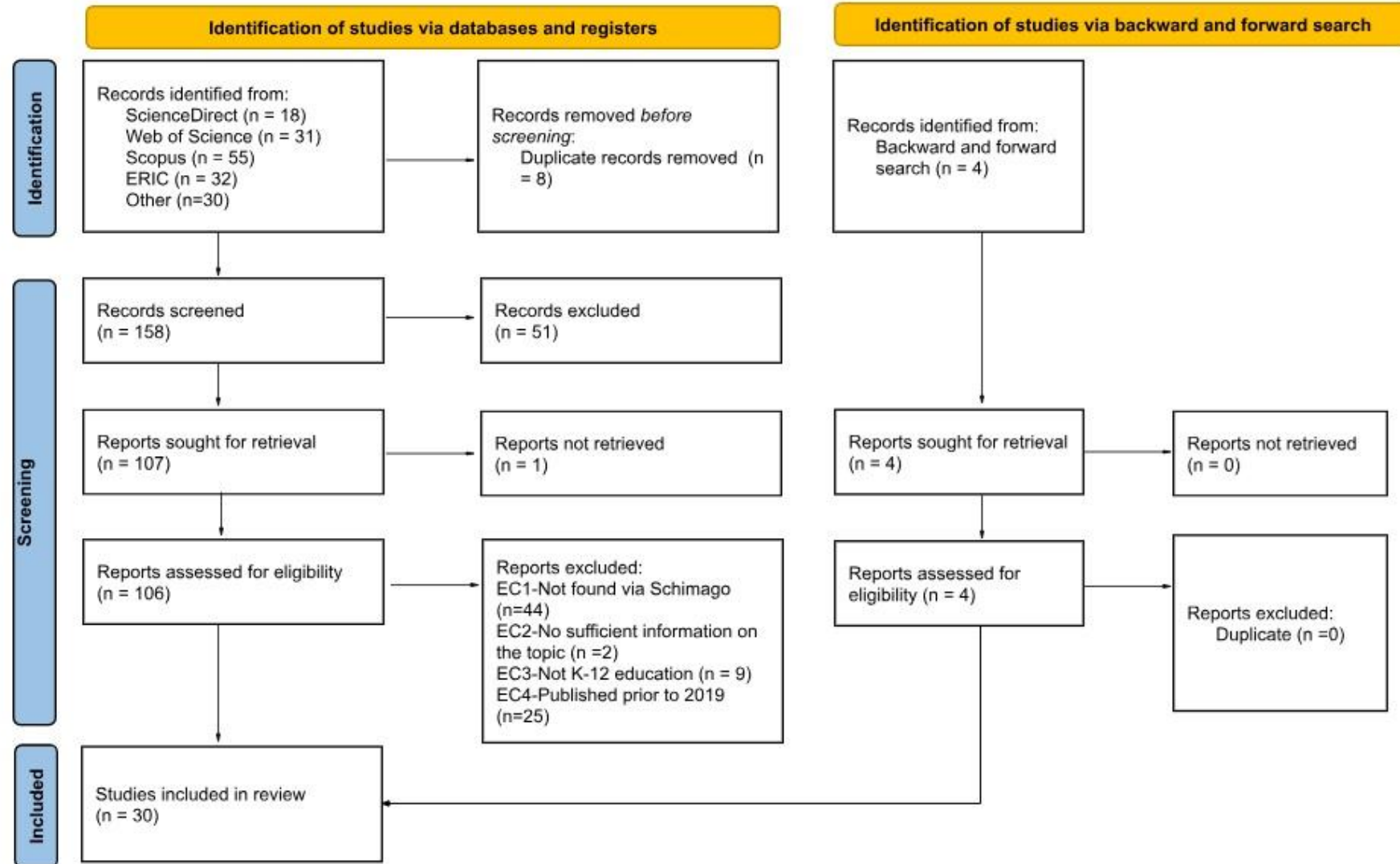


Figure 1. PRISMA flow Diagram

“Trinity of learning design” framework

	Description	Example
Tools	Include all materials and tools to be used for teaching and learning	Computers, mobile devices, robots etc.
Techniques	Include all pedagogies and approaches to teaching and learning	Computer supported learning, collaborative learning, games/simulations etc.
Ingredients	Include the content domain, learning objectives, feedback, etc.	Language, mathematics, science etc.

Table 1. Overview of the “Trinity of learning design” framework by Wasson and Kirschner (2020)

What are the current goals and learning design practices in using metaverse technology in K-12 education?

What are the current goals in using metaverse technology in K-12 education?

Category	Subcategory	Study
Metaverse and Learning Outcomes	Academic Skills Development	Testing game-based education for road safety (Saeed et al., 2023)
		Chemistry classroom through game-based Metaverse learning (Rahman, Wahid, Ahmad, & Ali, 2024)
		Immersive virtual reality field trip on climate change (Makransky & Mayer, 2022)
		Mobile AR learning for science outcomes (Marini et al., 2022)
	Digital Literacy and Critical Thinking	Virtual Learning Community for digital literacy (Netniyom & Chatwattana, 2024)
		Blockchain concepts and digital literacy (Leung et al., 2024)
		Meta-STEM for critical thinking (Rachmadtullah et al., 2023)
	Creativity and Innovation	Parallel-Twin-Worlds for treasure-hunting (Kinnula, Nakatani, Ryota, & Taoka, 2024)
		Creativity and social regulation in painting (Guan, Wang, Wang, Zhu, & Hwang, 2023)

What are the current goals in using metaverse technology in K-12 education?

Category	Subcategory	Study
Student-Centered Learning Approaches	Constructivist and Personalized Learning	Constructivist learning in primary schools via the metaverse (Suh & Ahn, 2022)
		Primary students redesigning school spaces (Dreamson & Park, 2023)
Metaverse for Special Needs and Inclusion	Inclusion and Support for Diverse Learners	Empowering deaf students through STEAM Metaverse projects (Mystakidis, Theologi-Gouti, & Iliopoulos, 2024)
		Enhancing social skills in HFASD students (Lee et al., 2023)
		Digital art therapy for ADHD students (Kim & Chung, 2024)

What are the current goals in using metaverse technology in K-12 education?

Category	Subcategory	Study
Teacher and Curriculum Integration	Teacher Preparation and Readiness	K-12 teachers developing Constructivist lesson plans (Lee & Kim, 2024)
		K-12 English digital textbooks via Metaverse (Hwang, 2024; Lee & Hwang, 2022)
	Perception and Adoption by Teachers	Teachers' experiences using the Metaverse (Çengel & Yildiz, 2022)
		Readiness for integrating Metaverse in high school classes (Romano et al., 2023)
Student Perceptions and Experiences	Metaverse in Subject-Specific Learning	Perceptions of Metaverse in mathematics classes (Reyes, 2020; Alfaisal, Hashim, & Azizan, 2024)
		Language learning through Metaverse (Guo & Gao, 2022; Lee & Ko, 2023)
		Science learning and STEAM experiences in Metaverse (Jafari, 2023)
	General Satisfaction and Experiences	Student satisfaction in Metaverse learning (Chang & Hsiao, 2024)
		Primary students' perceptions of learning in Metaverse (Alfaisal et al., 2024)
Technology and Safety Considerations	Safety and Environment	Perceived safety in Metaverse learning environments (Capatina et al., 2024)
	Immersive Technology in Education	Heritage involvement through Metaverse courses (Lee, 2023)

What are the current learning design practices in using metaverse technology in K-12 education? (Techniques)

Theoretical Approaches

Constructionism

Lee and Kim (2024)

Constructivism

Suh and Ahn (2024)

Situated Learning

Leung et al. (2024)

Learner-Centered Education

Suh and Ahn (2024)

Informal Learning

Lee (2023), Mystakidis et al. (2024)

Pedagogical Approaches

Collaborative Learning

Dreamson and Park (2023), Guan et al. (2023)

Gamification and Game-Based Learning (GBL)

Kim and Chung (2024), Lan et al. (2024), Saeed et al. (2023), Rahman et al. (2024)

Self-Directed Learning

Lan et al. (2024)

Experiential Learning

Guo and Gao (2022), Leung et al. (2024), Romano et al. (2023)

Situational Learning

Guo and Gao (2022)

STEM/STEAM Learning

Jafari (2023), Rachmadtullah et al. (2023), Mystakidis et al. (2024)

Inquiry-Based Science Learning (IBSL)

Makransky and Mayer (2022)

What are the current learning design practices in using metaverse technology in K-12 education? (Tools)

Tools	Indicative Literature
Mirror Worlds	Suh and Ahn (2022)
Augmented Reality	Suh and Ahn (2022) Saeed et al. (2023) Reyes (2020) Marini et al. (2022)
Virtual Reality	Dreamson and Park (2023) Suh and Ahn (2022) Lan, Shih and Hsiao (2024) Lee (2023) Lee et al. (2023) Lee and Kim (2024) Lee and Ko (2023) Lee and Hwang (2022) Hwang (2024) Makransky and Mayer (2022) Mystakidis, Theologi-Gouti and Iliopoulos (2024) Saeed et al. (2023) Romano et al. (2023) Rahman, Wahid, Ahmad and Ali (2024) Rachmadtullah et al. (2023)
Life Logging	Suh and Ahn (2022)

What are the current learning design practices in using metaverse technology in K-12 education? (Tools)

Tools	Indicative Literature
Digital Twin	Kinnula, Nakatani, Ryota and Taoka (2024) Saeed et al. (2023)
Internet of Things (IoT)	Saeed et al. (2023)
Artificial Intelligence (AI)	Leung et al. (2024) Saeed et al. (2023)
Non-Fungible Tokens (NFTs)	Leung et al. (2024) Saeed et al. (2023)
Custom-Made VR Software	Lee (2023) Rahman, Wahid, Ahmad and Ali (2024) Netniyom and Chatwattana (2024)

What are the current learning design practices in using metaverse technology in K-12 education? (Tools)

Tools	Indicative Literature
VR Mobile Applications	Saeed et al. (2023) Romano et al. (2023)
AR Mobile Applications	Reyes (2020) Marini et al. (2022)
Mobile or Other Handheld Devices	Saeed et al. (2023) Romano et al. (2023) Rahman, Wahid, Ahmad and Ali (2024)
Teleconferencing Platforms	Lee (2023) Lee et al. (2023) Kim and Chung (2024)
Web-Based / Mobile Applications	Kim and Chung (2024)
3D Character Software	Hsu and Lee (2020)

What are the current learning design practices in using metaverse technology in K-12 education? (Ingredients)

Domain

Art: Guan, Wang, Wang, Zhu and Hwang (2023)

Social Interactions: Kinnula, Nakatani, Ryota and Taoka (2024); Lee et al. (2023); Mystakidis, Theologi-Gouti and Iliopoulos (2024); Suh and Ahn (2022)

Mathematics: Alali and Wardat (2024); Reyes (2020)

Language Learning: Lan, Shih and Hsiao (2024); Lee and Kim (2024); Lee and Ko (2023); Lee and Hwang (2022); Guo and Gao (2022); Hwang (2024); Romano et al. (2023)

Road Safety: Saeed et al. (2023)

Culture/Heritage: Lee (2023); Romano et al. (2023)

Environmental Studies: Makransky and Mayer (2022)

Chemistry: Rahman, Wahid, Ahmad and Ali (2024)

Digital Literacy/Digital Citizenship: Leung et al. (2024); Mystakidis, Theologi-Gouti and Iliopoulos (2024); Netniyom and Chatwattana (2024)

What are the current learning design practices in using metaverse technology in K-12 education? (Ingredients)

Domain

Home Economics/Life Skills: Romano et al. (2023)

Science: Jafari (2023); Romano et al. (2023); Marini et al. (2022)

Special Education: Kim and Chung (2024); Lan, Shih and Hsiao (2024); Lee et al. (2023); Mystakidis, Theologi-Gouti and Iliopoulos (2024)

STEM/STEAM: Jafari (2023); Mystakidis, Theologi-Gouti and Iliopoulos (2024); Rachmadtullah et al. (2023)

What opportunities and barriers are inherent to the adoption of metaverse technology in K-12 education?

What opportunities and barriers are inherent to the adoption of metaverse technology in K-12 education?

Barriers

Lack of Digital Literacy / Misconceptions: (Jafari, 2023; Netniyom and Chatwattana, 2024; Suh and Ahn, 2022; Reyes, 2020; Lee and Ko, 2023; Lee and Hwang, 2022; Hwang, 2024).

Experience from Student's Perspective: (Suh and Ahn, 2022; Mystakidis, Theologi-Gouti and Iliopoulos, 2024; Kim and Chung, 2024; Lee et al., 2023; Alfaisal, Hashim and Azizan, 2024).

Distraction / Overuse: (Reyes, 2020).

Perceived Usefulness: (Alfaisal, Hashim and Azizan, 2024; Lan, Shih and Hsiao, 2024; Çengel and Yildiz, 2022).

Access to Technology and Costs of Acquisition/Set Up: (Makransky and Mayer, 2022; Romano et al., 2023).

Need for Comparative Studies: (Rahman, Wahid, Ahmad and Ali, 2024).

Safety and Privacy Concerns: (Capatina et al., 2024; Kinnula, Nakatani, Ryota and Taoka, 2024; Çengel and Yildiz, 2022).

What opportunities and barriers are inherent to the adoption of metaverse technology in K-12 education?

Opportunities

Collaboration/Community: (Dreamson and Park, 2023).

Customization/Individualization: (Suh and Ahn, 2022; Alali and Wardat, 2024; Kim and Chung, 2024).

Critical Thinking Skills: (Rachmadtullah et al., 2023).

Enhanced Creativity: (Alali and Wardat, 2024; Guan, Wang, Wang, Zhu and Hwang, 2023).

Engagement/Motivation: (Rahman, Wahid, Ahmad and Ali, 2024; Kim and Chung, 2024; Lan, Shih and Hsiao, 2024; Leung et al., 2024; Makransky and Mayer, 2022; Mystakidis, Theologi-Gouti and Iliopoulos, 2024; Rachmadtullah et al., 2023; Romano et al., 2023; Marini et al., 2022; Reyes, 2020).

Immersion/Realism: (Guo and Gao, 2022; Makransky and Mayer, 2022; Rachmadtullah et al., 2023; Saeed et al., 2023; Guan, Wang, Wang, Zhu and Hwang, 2023; Lee, 2023).

Inclusion: (Rachmadtullah et al., 2023; Suh and Ahn, 2022; Lee and Ko, 2023; Lan, Shih and Hsiao, 2024; Mystakidis, Theologi-Gouti and Iliopoulos, 2024; Kim and Chung, 2024; Lee et al., 2023).

Understanding: (Reyes, 2020; Rahman, Wahid, Ahmad and Ali, 2024; Marini et al., 2022; Leung et al., 2024).

Retention: (Reyes, 2020; Makransky and Mayer, 2022; Marini et al., 2022).

Safety: (Rachmadtullah et al., 2023; Saeed et al., 2023).

Conclusion

*Our findings underscore both the innovative practices and the common obstacles faced by educators when integrating metaverse technologies. While these **studies predominantly highlight the outcomes of metaverse-enhanced learning experiences**, there is a crucial need for more studies to examine and analyze the learning design process involved. Understanding and developing effective learning designs are essential, as they guide the creation of pedagogically sound and engaging educational experiences.*

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