Cultivating Learning through Immersive Technologies in Israeli Formal Education Classrooms

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Abstract

This qualitative study explores the integration of two immersive technologies – immersive rooms and virtual reality headsets – within Israeli formal education classrooms. It examines their pedagogical affordances to the learning process based on lesson observations and educator interviews. An analysis of the learning activities and interview statements used two frameworks: the e-CSAMR model combining the SAMR framework assessing the added pedagogical value of the technology together with a digital teamwork categorization and a teaching typology distinguishing between teacher-centric to student-centric instruction. Findings reveal that Immersive Rooms are mostly used to *substitute* and *augment* existing pedagogical practices, fostering group interactions with teacher-centric facilitation roles. Virtual Reality headsets possess potential for pedagogical modification and student-driven learning, though their current use remains limited. While both technologies motivate and engage, they are often implemented to deliver pre-designed teacher-facilitated content rather than enabling open exploration and creativity. The study suggests that realizing the transformational potential of immersive technologies requires developing new pedagogical approaches tailored to their distinctive affordances,

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combined with technological training and ongoing support. This will enable moving from teacher-centric *augmentation* towards student-driven *redefinition* of learning processes using these cutting-edge environments.

Keywords: Immersive Educational Technologies, VR learning, Collaborative Digital Teamwork.

Literature Review

Intro

As immersive technologies become more accessible, educational institutions in Israel are increasingly learning how to incorporate them to enhance learning and motivate students through student-centered pedagogical approaches. The current study examines the potential pedagogical and collaborative value of two immersive technology modalities – immersive rooms (IR) and Virtual Reality headsets (VR) – within the early stages of their integration in schools. This examination is done by assessing the level of technology integration (Puentedura, 2016), characteristics of teamwork in technological contexts (Shamir-Inbal & Blau, 2021), and teaching prototypes (Yondler & Blau, 2023).

Immersive technologies in education

Immersive technologies differ in the immersive and interactive experiences they offer. On one end of the continuum are immersive rooms (IR), where entire rooms are transformed into digitally interactive spaces. These rooms are equipped with interactive screens on the three walls and floor, facilitating collective virtual reality experiences. They are currently being deployed in educational institutions in Israel, often accompanied by additional learning spaces to accommodate larger student groups. At the other end of the continuum are Virtual Reality headsets, which involve using a headset that submerges the user's senses within virtual reality. VR technology is used in varying levels of sophistication, from simple smartphone-based cardboard headsets to high-end VR headsets. The continuum also includes hybrid technology, such as Augmented Reality where VR is used to virtually project objects onto the environment.

The use of immersive technologies in education holds significant promise. Immersive technologies can enable learners to explore otherwise inaccessible or hazardous environments and engage in experiences that were previously beyond their reach. These immersive learning environments foster heightened presence and engagement, ultimately contributing to increased retention and knowledge transfer (Makransky & Lilleholt, 2018; Petersen et al., 2020; Makransky & Mayer, 2022). In particular, immersive VR is currently leveraged to facilitate various learning processes such as exploration, experimentation, rote learning, communication, and creativity (Villena Taranilla et al., 2022; Chen, 2022; Zhang et al., 2022; Mourtzis & Mystakidis, 2022; Wang & Lai, 2023; Mystakadis, 2022). However, despite being a relatively novel educational tool, several challenges have already emerged, including concerns related to cognitive overload (Petersen et al., 2020), privacy safeguards, potential antisocial behavior (Kun, 2022), and the physical effects of prolonged headgear use (Israel et al., 2017; Martirosov et al., 2022; Wang et al., 2022b).

e-CSAMR

The SAMR framework (Puentedura, 2016) analyzes the added value of technology in the educational learning process. SAMR defines four levels of technology's significance within the pedagogical process. The lower two tiers in the framework (S=*Substitution* and A=*Augmentation*) represent the enhancement stages where technology enriches the lesson but has not substantially changed it. The two higher tiers (M=*Modification* and R=*Redefinition*) represent the transformation stages where the lesson plan has reformed itself because of technology integration. SAMR has been employed in prior studies to analyze both virtual reality and augmented reality (Romrell et al., 2014; Frydenberg & Andone, 2018). In these studies, VR use demonstrated various SAMR levels, ranging from the lowest level of Substitution to the highest level of Redefinition, contingent on the pedagogical approach employed.

A central characteristic of immersive VR is the ability to foster socialization and collaboration among users within virtual reality spaces (Wiederhold, 2022). A recent **e-CSAMR** framework (Shamir-Inbal & Blau, 2021) integrated digital teamwork levels into the SAMR model. E-CSAMR defines three types of digital teamwork: *Knowledge Sharing,* in which the students work individually and create a shared database of their knowledge; *Cooperation*, where participants divide tasks and perform them individually to create a group learning outcome; and *Collaboration*, where students design and work together on their group learning outcome. Analyzing the quality of peer collaboration in immersive VR based on the e-CSAMR model mapping indicates the added value of this technology to collaborative teaching-learning processes and outcomes.

Typology of teaching prototypes

Evaluating immersive technology integration requires an understanding of the ways to conduct lessons in that context. The typology of teaching prototypes defines four teaching roles involving integrating technology in the classroom. The four roles correspond to the degree of the teachers' centrality in the classroom (Yondler & Blau, 2023; Yondler et al., 2018). The *sage* teaching prototype is the dominant teacher, leading and controlling the instruction. The *facilitator* enables students' independent learning or teamwork in well-structured and clearly defined learning environments. The *guide* works with the students to discover and construct their knowledge, while enabling them to choose their learning path. The *partner* envisions the teacher's role as learning and discovering alongside students and even from them. It is reasonable to assume that the same connections between teaching typology and pedagogical strategies that teachers employ in a more traditional technology-enhanced classroom will also exist in immersive environments integrated instruction, Thus, these frameworks can be used to analyze immersive technology integration in the classroom.

Research Aims and Objectives

This research examines the initial integration of immersive technologies in several schools in Israel focusing on student-centered collaborative learning. Accordingly, the research accompanied schools' initial steps in immersive technologies assisted learning by interviewing the teachers and observing the lessons with the goal of analyzing the learning activities.

The study explored the following research questions:

1. What are the pedagogical characteristics of **learning processes** in IR-assisted and VR-assisted immersive learning?
2. What **teaching prototypes** are prevalent in IR-assisted and VR-assisted instruction?

Methodology

This study adopts a qualitative approach to conduct multiple case studies on the integration of immersive technology. The immersive technology employed was accessed through two distinct modalities: immersive rooms (IR) and head-mounted virtual reality displays (VR). Given that both these technologies are still in their early developmental stages in the Israeli education system, utilizing a qualitative paradigm will provide an in-depth understanding of participants' experiences and attitudes toward their adoption and integration (Leavy, 2022).

Research context

This research study involved conducting lesson observations and interviews with teachers in schools that have integrated immersive technologies into their learning environments. All schools were in their initial stages of utilizing immersive technologies. Table 1 describes the schools participating in the research.

Table 1. Overview of participating schools in the research.

	School Age Group	School Type	Technology	Student Ages observed	Topics
1	Elementary	Hebrew-speaking state school	IR	10-11 yrs	Geography
2	Elementary	Hebrew-speaking state school	VR	10-11 yrs	Science
2	Elementary	Hebrew-speaking state school	VR	10-11 yrs	History
3	Middle	Hebrew-speaking state school	IR	13-14 yrs	History
4	Middle	Hebrew-speaking state school	VR	12-14 yrs	History
5	Middle + High	Hebrew-speaking state school	IR	16-17 yrs	English, History
6	Middle + High	Arabic-speaking state school	VR	12-14 yrs	History

Participants

The study included participants from three participant groups – teachers, ICT school coordinators, and instructional training designers — all integrating either immersive classrooms or immersive VR into their instruction, as detailed in Table 2. Participants were recruited either through designated educational technology groups on social media or through two laboratories of the Israeli Ministry of Education Research & Development unit on IR and VR integration. Table 2 describes the participants, the technology they integrate, and their learning topics.

Table 2. Participants, integrated technology, and learning topics overview

	Technology	Participants (N=9)	Male (N=5)	Female (N=4)	Topics
Teacher	IR	3	1	2	History, English, Maths, Geography
	VR	2	1	1	Biology, History
ICT school coordinators	IR	1	0	1	All topics
	VR	1	1	0	All topics
Training Designers	IR	1	1	0	All topics
	VR	1	1	0	English, Safety Training

Instruments

The research tools used in this research were interviews and lesson observations. In total, 9 interviews and 17 observations were collected.

Semi-structured interviews were conducted with the participants to obtain an in-depth perspective of their views and practice. In the interviews, all participants were asked to elaborate on the reasons they integrate immersive technology, as well as provide detailed explanations of their lesson plans, teaching, and assessment methods. Interviews with all the study participants were approximately 45 minutes and were conducted via a videoconferencing system thus enabling participants from all over the country to schedule interviews at times that suited them.

Lesson observations were collected by a non-participant observer, to evaluate the instruction and assessment strategies and students' learning experience. The observations focused on following the integration of immersive technology in instruction and learning: monitoring the lesson flow, students' learning process, and the role the teacher takes in a lesson. Observations spanned a single lesson, lasting approximately 45 minutes. These observations took place in immersive and VR-enhanced classrooms, allowing for firsthand examination of face-to-face interaction among the participants.

Data Analysis

The interviews were recorded and transcribed for analysis. Then, the lesson plans were extracted from classroom observation summaries and the interviews in which the participants detailed the lessons taught. These plans were divided into 53 units of cohesive learning activities (44 activities from lesson observations and 9 activities from interviews). The learning activities were analyzed top-down using thematic analysis according to the frameworks detailed above– e-CSAMR (Puentedura, 2014; Shamir-Inbal & Blau; 2021) and Teacher Prototypes (Yondler et al., 2018; Yondler & Blau, 2023). The interviews were analyzed separately according to the same frameworks and statements. For inter-rater reliability, 25% of the statements were independently re-coded by a second rater specializing in learning technologies, and a high level of inter-rater reliability was found (Cohen's Kappa = 0.84).

Ethics

The study was approved by the Chief Scientist of the Israeli Ministry of Education (MoE) and the institutional Ethics Committee.

Findings and Discussion

To address the first research question, the pedagogical characteristics of the learning process were examined using the e-CSAMR framework. Subsequently, in response to the second research question, the teacher's role in learning, classified according to the teaching typology, was analyzed to identify prevailing prototypes. Each category is accompanied by a table displaying the frequency of statements, and subsequent tables showcase representative statements extracted from both activities and interviews.

RQ1. To examine the pedagogical characteristics of learning processes, this study analyzed the data using the e-CSAMR framework, which combines the SAMR framework indicating the level of added value that immersive technology offers, along with a digital teamwork categorization. Table 3 presents the number of statements found in each immersive technology, IR, and VR, along with their respective SAMR categorizations (*Substitution, Augmentation, Modification, Redefinition*). The statements are divided into those arising from the activities and those derived from the interviews. Table 4 and Table 5 display representative quotes for every SAMR integration level from the learning activities and interviews respectively.

Table 3. SAMR technology integration levels

Learning Activities (n=33)					Interviews (n=140)				
	S	**A**	**M**	**R**		**S**	**A**	**M**	**R**
IR (n=22)	9 (41%)	9 (41%)	4 (18%)	0 (0%)	**IR (n=57)**	10 (18%)	31 (54%)	11 (19%)	5 (9%)
VR (n=11)	2 (18%)	3 (27%)	3 (27%)	3 (27%)	**VR (n=83)**	17 (20%)	34 (41%)	26 (31%)	6 (7%)
Total (n=33)	11	12	7	3	**Total (n=140)**	27	65	37	11

Table 4. SAMR technology integration levels– representative learning activities

	SAMR	Representative Learning Activities
IR	**S**	Students sit on the floor in the immersive area. An introductory video about Jerusalem and its historical periods is screened in the immersive space. The teacher then asks the students questions to assess their understanding of the video. (IR3)
	A	Students working in small groups. They read a text from the immersive wall, together with descriptive graphics about the Dead Sea and how to save its resources. The students then receive sentences about the text and sort them according to the order they appeared in the text. (IR5)
	M	Students prepare photos and texts about Holocaust victims. The teacher uploads the content into the immersive room software. Students then present their content in the immersive room with atmospheric music in the background. (IR7)
	R	N/R (Did not exist in our corpus)

VR	S	Students enter the virtual space, they learn how to create their avatar and customize it according to their needs, they practice moving their avatar around in the virtual space. (VR2)
	A	Students worked in groups of three or four. They accessed the VR simulation of planet Mars through the VR. Each student puts on the VR headset and spends 3 minutes exploring the planet and then transfers the headset to the next student. (VR1)
	M	Students [from different schools] enter the virtual space. Each group uploads a presentation, and the students present it to each other. The presentations are about a location that contains a historical conflict context. (VR2)
	R	Students from different schools enter a virtual space simulating the human body, specifically the nose. The teacher requests that they explore their surroundings and then they identify the internal nose components. (VR4)

Table 5. SAMR technology integration levels– representative interview statements

	SAMR	Representative Interviews Statements
IR	S	I am teaching them vocabulary... what I want to do is leverage the room experience to teach them English in places around the world…These three walls can take you to other places. (IRTE1)
	A	The students are more interested, more motivated, their eyes are shining when they work in the immersive room, they just want to touch the walls and learn (IRC1)
	M	As far as I am concerned – the 3 immersive walls are 3 extra teachers in the classroom…. you can divide your class into smaller workgroups, and you build the lesson so that each workgroup can learn independently (IRC1)
	R	The only way to get really good results is if the students build the lessons themselves. I have two students who built a science lesson in the immersive room (IRTE1)
VR	S	In the first lesson we spent most of the time getting to know VR, building avatars, and learning how to move in the virtual space (VRC1)
	A	VR enables us to diversify the instruction, learning, and assessment and not stay frozen in time. It helps us constantly stimulate the students, and change the way we teach (VRC1)
	M	VR can do something that other technologies cannot do, it enables a learning experience and also enables them to be in a place that is not school and breaks the boundaries of the school - mental and physical boundaries of the students too. (VRT3)
	R	The students studied the historical street (in VR) and then researched more on each of the sites they experienced in the VR. It was like a school trip, but they didn't leave the school. (VRT3)

Based on the SAMR categorization in Table 3, it appears that the integration of immersive technology was primarily done in the three lower levels – *Substitution, Augmentation, and Modification*. *Redefining* the pedagogical value of the lesson is not prominent in either technology. However, a close examination of the differences between the analysis of IR and VR, shows that while IR predominantly focuses on *Substitution* and *Augmentation*, VR possesses the potential capacity to emphasize the higher levels of modifying the pedagogical value of the lesson. This difference may be attributed to the limitations of IR in terms of the variety of media and self-exploration that students can engage in within the immersive space, limiting the opportunity to use this technology for *redefining* the pedagogy in lessons. In contrast, VR exhibits a stronger presence in the *Modification* category due to its unique ability to bring people from various locations together in one connected VR space and the distinctive learning experiences it offers. Based on the interview statements found in Table 3 and Table 5, participants recognize the potential of immersive technology to *redefine* and *transform* learning but mostly they see it as one more technology to diversify the instruction and learning and motivate the learners.

The e-CSAMR framework combines the SAMR framework with a categorization of student e-collaboration to show the extent to which students' collaboration is improved by using new technology. Table 6 displays the student collaboration categorization (*None*, *Knowledge Sharing*, *Cooperation*, *Collaboration*), including the number of statements in each category and the distribution of categories between activities and interviews. Table 7 and Table 8 present a representative quote from the learning activities and interviews respectively.

Table 6. E-collaboration levels

Learning Activities (n=35)					Interviews (n=127)				
	None	**Knowledge Sharing**	**Cooperative**	**Collaboration**		**None**	**Knowledge Sharing**	**Cooperative**	**Collaboration**
IR (n=22)	10 (45%)	1 (5%)	0 (0%)	11 (50%)	**IR (n=49)**	32, 65%	4, 8%	0, 0%	13, 27%
VR (n=13)	9 (69%)	3 (23%)	1 (8%)	0 (0%)	**VR (n=78)**	60, 77%	18, 23%	0, 0%	0, 0%
Total (n=35)	19	4	1	11	**Total (n=127)**	92	22	0	13

Table 7. E-collaboration levels in learning activities

Tech	Collaboration Level	Learning Activity Description
IR	None	N/R
	Knowledge Sharing	The teacher …asks them to examine the walls simulating the dead sea beach and write questions on a joint online padlet using their ipads. The teacher then reads out the questions the students wrote. (IR5)
	Cooperation	N/R (Did not exist in our corpus)
	Collaboration	Groups of 2-3 students are solving a mathematical mystery. To solve the questions, they need to seek the correct graphical object on the wall of the immersive space and scan it on their iPads. Once scanned, the information about the object pops up. (IR1)
VR	None	N/R
	Knowledge Sharing	Students are in the VR space, student shows a presentation about the city of Beet Shaan. At the end, the teacher quizzes the students on the information learned. (VR3)
	Cooperation	N/R (Did not exist in our corpus)
	Collaboration	N/R (Did not exist in our corpus)

Table 8. E-collaboration levels in interviews

Tech	Collaboration Level	Interview Quote
IR	None	N/R
	Knowledge Sharing	The students had a free lesson, so I took them to the immersive room and they played a group maths game that practiced the multiplication table. …the competition between them got them really excited (IRT1)
	Cooperation	N/R (Did not exist in our corpus)
	Collaboration	In this pedagogical model, the students are active, they prepare the lesson and teach it and the students they teach it too, are also active and participate in the lesson (IRT1)
VR	None	N/R
	Knowledge Sharing	Then comes the third part (of the lesson) where we collaborate with the second school, and there we engage in activities where they ask us, "What's your name, and what do you like to do in life?" like that. (VRT2)
	Cooperation	N/R (Did not exist in our corpus)
	Collaboration	N/R (Did not exist in our corpus)

As can be seen in Tables 6 – 8, IR appears to be more conducive to fostering *collaborative* activities within the immersive space. This is understandable since IR spaces are designed for lessons in which students interact with each other and with the walls. These lessons can either involve each group of students focusing on separate walls or collectively searching for objects within the immersive space alongside their colleagues as in a multiplication game. *Knowledge sharing* and *cooperation* are rarely identified within the IR. Indeed, it seems that IR primarily fosters group dynamics with less space for individual work time essential to effective *cooperative* learning activities (Abdu & Schwarz, 2019).

In contrast, the use of VR in schools predominantly promotes individual exploration, with limited options for group work within the virtual space. This does not imply that group work in VR is impossible; rather, it currently remains individualistic. This might be due to the higher technological requirements for multiplayer activities in VR.

RQ2. As explained above, the teaching typology defines four teaching prototypes (*sage, facilitator, guide, and partner).* Table 9 displays the prototypes, including the number of statements in each category and the distribution of categories between activities and interviews. Table 10 and Table 11 present a representative quote from the learning activities and interviews respectively.

Table 9. Teaching types in learning activities and interviews

Learning Activities					Interviews				
	Sage	**Facilitator**	**Guide**	**Partner**		**Sage**	**Facilitator**	**Guide**	**Partner**
IR (n=22)	6 (27%)	15 (68%)	1 (5%)	0 (0%)	**IR (n=78)**	4 (5%)	62 (79%)	6 (8%)	6 (8%)
VR (n=13)	3 (23%)	6 (46%)	4 (31%)	0 (0%)	**VR (n=91)**	11 (12%)	67 (74%)	12 (13%)	1 (1%)
Total (n=35)	9	21	5	0	**Total (n=169)**	15	129	18	7

Table 10. Teaching prototypes in learning activities

	Teacher Prototypes	**Learning Activity Description**
IR	Sage	Students sit outside the immersive area. The teacher sits inside and uses the immersive room walls to project content relating to the history of the school. (IR6)
	Facilitator	After watching a short movie about Biotic factors [organisms] in the immersive space all students answer an online quiz on their iPads. (IR2)
	Guide	For a Remembrance Day activity, students prepare material about fallen soldiers. The teacher uploads the materials into the immersive room space software. The students then stand next to the photo of the soldier [in the immersive space] they wrote about and present the information to the visitors. (IR7)
	Partner	---
VR	Sage	Students and Teacher enter the VR space. The teacher mutes the students and explains the biology material that will be presented in the lesson. The teacher then asks questions to ensure the students are aware of all the basic concepts. (VR4)
	Facilitator	Students follow a learning path in their desktop portfolio. For every location station in their learning path, they explore the location in VR and then answer the questions in their portfolio. (VR5)
	Guide	Students bring prepared speeches they have written in English about their hobbies. Each student puts on the VR headset and practices his speech. The software gives the students feedback on the speech and the student fixes it. The teacher walks around the students and provides extra content feedback (VR6).
	Partner	---

Table 11. Teaching prototypes in interviews

	Teaching Prototype	Interview Quote
IR	Sage	In this lesson I [teacher] stand in front of the immersive room and demonstrate the material on the walls. I then call the students into the immersive area and tells them what to do. (IRC1)
	Facilitator	In one activity the students scanned a barcode from the immersive walls and opened a Google form. In the form, they could watch a movie clip with a story of one of the holocaust survivors. They could choose which one they watched and then they filled in the form with the answers to questions about the movie clip they watched. (IRT1)
	Guide	In my opinion, the immersive room is supposed to stimulate and enable student investigation. (IRT2)
	Partner	We have built this model where the digital immersive area will enable students to learn independently…the students will learn to become inventors, with new ideas..ask questions and develop things on their own…(IRC1)
VR	Sage	Our main goal was that the students would get to know the pioneer's path in our hometown (VRC1)
	Facilitator	I want the students to go into a 360-degree movie of their choice, experience it, and then go back into the physical world (VRT2)
	Guide	The pedagogical guide told us that we must have more student self-inquiry, the students must initiate and be active otherwise it would be exactly like the regular class (VRT1)
	Partner	If we could continue, we would send the students to shoot, investigate, add, and build their materials and portfolio – create their learning materials but that is the next stage (VRT3)

The analysis of teaching prototypes shows that for both immersive modalities, teachers' actions correspond with *Sage* and *Facilitator* prototypes of the typology. In the case of IR technology, the lesson demands a significant amount of preparation, as the teachers mentioned in their interviews. The walls themselves contain preassigned information and activities, encouraging independent student work but in a highly structured manner based on the content that the teacher designed. There is no room within the direct immersive space for independent inquiry.

VR activities primarily followed the *Sage* teacher prototype, with the teacher leading the student experience. For example, a teacher conducted a meeting with students from other schools, or a teacher guided the students through a simulation of the human body. In these situations, the student experience was considered significant enough to justify the use of immersive technology. Furthermore, it appears that, since these instances represented the initial use of VR technology, the teachers were not yet comfortable allowing students the freedom to explore the VR space. They often muted and controlled students' speech and movements. However, the interview quotes indicate that teachers do not necessarily view their role in VR as that of a *sage* but rather as a *facilitator*. In both technologies, it appears that teachers do not initially view immersive technologies as tools for independent exploration of students.

This study highlights the current use of immersive technologies in formal education in Israel. According to the e-CSAMR categorization, Immersive Rooms in schools participating in the study were primarily used for *Substitution* and *Augmentation*, emphasizing group interactions and collective exploration, and limiting possibilities for individual exploration or creativity within the immersive space. These findings highlight the distinctive features of Immersive Rooms, differing from prior e-CSAMR analyses often showing higher SAMR levels but lower collaborative engagement (Shamir-Inbal & Blau, 2021). VR has the potential for higher pedagogical *modification* and collaboration, as indicated in the literature on Metaverse and Collaborative VR in education (Laine & Lee, 2023; Makransky & Peterson, 2023). However, its implementation appears limited, possibly due to technological limitations. The analysis of teaching roles in both environments shows that Immersive Room teachers favor *Sage* and *Facilitator* teaching styles, while VR potentially encourages teachers to adopt *Guide* teaching styles. These findings underscore that realizing the transformational potential of immersive technologies requires using appropriate pedagogical approaches tailored to leveraging their distinctive affordances**.** This can only work if combined with technological training and support to foster independence and creativity in learning processes.

References

Abdu, R., & Schwarz, B. (2020). Split up but stay together: Collaboration and cooperation in mathematical problem solving. *Instructional Science, 48,* 313-336. https://doi.org/10.1007/s11251-020-09512-7

Chen, Z. (2022). Exploring the application scenarios and issues facing Metaverse technology in education. *Interactive Learning Environments*, 1-13. https://doi.org/10.1080/10494820.2022.2133148

Frydenberg, M., & I, D. (2018). Enhancing and transforming global learning communities with augmented reality. *Journal of Information Systems Education*, *29*(1), 37.

Israel, K., Zerres, C., & Tscheulin, D. K. (2017, September). Reducing cybersickness: The role of wearing comfort and ease of use. In *Frontiers in Optics* (pp. JTu2A-113). Optica Publishing Group. https://doi.org/10.1364/FiO.2017.JTu2A.113

Kun, Y. U. E. (2022). The Metaverse in the Psychoanalytic Perspective: The Unleashed Human Id in the Metaverse. *Psychology, 12*(1), 6-10. http://dx.doi.org/10.17265/2159-5542/2022.01.002

Leavy, P. (2022). *Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches*. Guilford Publications.

Laine, T. H., & Lee, W. (2023). Collaborative Virtual Reality in Higher Education: Students' Perceptions on Presence, Challenges, Affordances, and Potential. *IEEE Transactions on Learning Technologies*. https://doi.org/10.1109/TLT.2023.3319628

Makransky, G., & Lilleholt, L. (2018). A structural equation modeling investigation of the emotional value of immersive virtual reality in education. *Educational Technology Research and Development, 66*(5), 1141-1164. http://dx.doi.org/10.1007/s11423-018-9581-2

Makransky, G., & Mayer, R. E. (2022). Benefits of Taking a Virtual Field Trip in Immersive Virtual Reality: Evidence for the Immersion Principle in Multimedia Learning. *Educational Psychology Review*, 1-28. https://doi.org/10.1007/s10648-022-09675-4

Makransky, G., & Petersen, G. B. (2023). The theory of immersive collaborative learning (TICOL). *Educational Psychology Review*, 35(4), 103. https://doi.org/10.1007/s10648-023-09822-5

Martirosov, S., Bureš, M., & Zítka, T. (2021). Cyber sickness in low-immersive, semi-immersive, and fully immersive virtual reality. *Virtual Reality, 26*(1), 15–32. https://doi.org/https://doi.org/10.1007/s10055-021-00507-4

Mourtzis, P., & Mystakidis, S. (2022). Improving Online Language Learning Interactivity with Multiuser Virtual Reality Environments: Preparing for the Metaverse. In *ICERI2022 Proceedings* (pp. 57-65). IATED. https://doi.org/10.21125/iceri.2022.0044

Mystakidis, S. (2022). Metaverse. *Encyclopedia, 2*(1), 486-497. https://doi.org/10.3390/encyclopedia2010031

Petersen, G. B., Klingenberg, S., Mayer R. M., Makransky G. (2020). The virtual field trip: Investigating how to optimize immersive virtual learning in climate change education. *British Journal of Educational Technology, 51*(6), 2098-2114. https://doi.org/10.1111/bjet.12991

Puentedura, R. (2014). Learning, technology, and the SAMR model: Goals, processes, and practice. Retrieved January 11, 2024 from http://www.hippasus.com/rrpweblog/archives/2014/06/29/LearningTechnologySAMRModel.pdf

Romrell, D., Kidder, L. C., & Wood, E. (2014). The SAMR Model as a Framework for Evaluating mLearning. *Journal of Asynchronous Learning Networks*, 18(2). http://dx.doi.org/10.24059/olj.v18i2.435

Shamir-Inbal, T., & Blau, I. (2021). Characteristics of pedagogical change in integrating digital collaborative learning and their sustainability in a school culture: e-CSAMR framework. *Journal of Computer Assisted Learning, 37*(3), 825-838. http://dx.doi.org.elib.openu.ac.il/10.1111/jcal.12526

Villena-Taranilla, R. V., Tirado-Olivares, S., Gutiérrez, R. C., & González-Calero, J. A. (2022). Effects of virtual reality on learning outcomes in K-6 education: A meta-analysis. *Educational Research Review, 35*, 100434–100434. https://doi.org/https://doi.org/10.1016/j.edurev.2022.100434

Wang, H., & Lai, P. C. (2023). Classroom Interaction and Second Language Acquisition in the Metaverse World. *Strategies and Opportunities for Technology in the Metaverse World* (pp. 186-195). IGI Global. http://dx.doi.org/10.4018/978-1-6684-5732-0.ch011

Wang, Y., Lee, L. H., Braud, T., & Hui, P. (2022b). Re-shaping Post-COVID-19 Teaching and Learning: A Blueprint of Virtual-Physical Blended Classrooms in the Metaverse Era. ArXiv. https://doi.org/10.1109/ICDCSW56584.2022.00053

Wiederhold, B. K. (2022). Ready (or Not) Player One: Initial Musings on the Metaverse. *Cyberpsychology, Behavior and Social Networking, 25*(1), 1–2. https://doi-org.elib.openu.ac.il/10.1089/cyber.2021.29234.editorial

Yondler, Y. & Blau, I. (2023). What is The Degree of Teacher Centrality in Optimal Teaching of Digital Literacy in a Technology-Enhanced Environment? Typology of Teacher Prototypes. *Journal of Research on Technology in Education*, 1-22. https://doi.org/10.1080/15391523.2021.1950084

Yondler, Y., Blau, I., Ben-Yehudah, G., & Eshet, Y. (2018). Different but equally effective? Four models for technology-enhanced optimal teaching of digital literacy skills. In *EARLI-Instructional Design & Educational Technology Meeting: Instructional Design and Technology for 21st Century Learning: Challenges, Solutions, and Future Directions.* Bonn, Germany.

Zhang, X., Chen, Y., Hu, L., & Wang, Y. (2022). The metaverse in education: Definition, framework, features, potential applications, challenges, and future research topics. *Frontiers in Psychology, 13*. https://doi.org/10.3389/fpsyg.2022.1016300