Innovating Education: Leveraging Constructivism, AI-Enhanced VR, and Adaptive Learning Platforms for Immersive Learning Experiences

Jason P. Boursier

Department of Education, Purdue University

Dr. Lowell, EDCI 531: Learning Theory and Instructional Design

Commented [GG1]: Hi Jason,
Thank you for sharing your writing with me again. During the session, I read through your paper (I was able to get through the whole thing but not make as many in-depth comments towards the end) and mainly made comments about clarity and transition sentences. I think that you made some really nice changes that really made your argument clearer and stronger! For your question about needing to add a source about behaviorism and cognitivism not being effective in VR, I'm not sure that is completely necessary. From your paper, it seems like the issues with using VR are not as much about the type of learning experience it can provide, but more about cost, access, maintenance, etc. I think making that clearer in the intro would be helpful rather than just bringing it up in the last paragraph. I think you could also mention your hypothesis that adding things like constructivism like active and reflective learning after the VR experience is also essential. I'm not sure that needs to go in the intro, but I think you could bring it up a little earlier when connecting VR with constructivism.
Overall, it seems like you have a very solid and logical organization of your resources that presents a compelling argument for how VR in conjunction with AI and the learning theory of constructivism can have a huge impact of the quality of education. Please feel free to come back whenever we can help!
-Genevieve

Introduction

The development of learning theories over time has grown alongside the technology used in classrooms and other training environments. This change includes virtual reality (VR), artificial intelligence (AI), and adaptive learning platforms, but first we must examine the history and how we got here in the modern era. From the onset, the practitioners of the learning theory behaviorism from the early 20th century utilized available technologies and incorporated a type of differentiated instruction called programmed instruction. This was used in learning environments to tailor instruction to individual student needs because in the 1950s B.F. Skinner modified Sidney Pressey's original testing machines of the 1920s to incorporate actual instruction that presented the information to students in small steps and then provided feedback for wrong answers (Schunk, 2020). Moving forward from using technology for conditioning, Frederic Bartlett later developed schema theory which contends that memory is a process of reconstruction (Bartlett, 1995), so cognitive theories like Cognitive Information Processing (CIP) became more widely used in educational settings. History shows how technology has been adapted in educational settings to better address how learners process and retain information. Later in the 20th century, Social Cognitive Theory was introduced by Albert Bandura and conceptualized that learning is most effective by social techniques like observation and modeling, and he emphasized that interactions between people, behaviors, and the learning environment is most important in educational settings (Schunk, 2020). In today's world VR and AI simulations are greatly influenced by social cognitive theory, and research shows how feedback and social rewards are used to support learning. In a recent study, Hu et al (2024) prove that "the emphasis on social rewards as a significant factor influencing anxiety-related neural patterns can be important for creating more advanced and context-aware computational models" (Hu et al, 2024, p. 11). Social rewards are important in the VR environment, but the most effective theory to consider when incorporating AI into the VR environment was popularized in

Commented [GG2]: I think you may be able to take this part out and combine with the next sentence. For example, "Present technological innovations include virtual……;however, from the onset, practitioners of…." This allows you to show the reader that this combination of tech and learning theories has been going on for a long time and is not a new developement

Commented [GG3]: I think this could be it's own sentence. For example, " In the 1950s, B.F. Skinner…"

Commented [GG4]: "History shows that technology can be adapted in…" might flow a little better

the late 1990s and is called constructivism. From the constructivist perspective, knowledge is not derived from external truths, but is formed internally by the learner (Schunk, 2020). Internal constructs of meaning well exceed the impact of social constructs of meaning, and this paper will focus on how constructivism in VR and AI assisted learning environments is used for scenario-based learning experiences to simulate real-world situations, delivering more impact to real challenges in the learners' performance context than behaviorist and cognitivist theories. While these theories are still popular in VR environments, they often prioritize structured, teacher-driven approaches to learning that are becoming less relevant with this new technology. This paper will argue that the advancement VR in conjunction with AI and the learning theory of constructivism will become paramount in these learner-centered environments, specifically adaptive learning platforms, and will help prove that these technologies provide the ideal environment for experiential, personalized learning to foster deeper engagement and understanding, now and in the future.

Commented [GG5]: Nice transition between ideas!

Commented [GG6]: This is very clearly stated!

Commented [GG7]: What/who is they referring to here?

Commented [GG8]: I think that you made your argument much more clear! My only question is what will this be replacing. You do mention structured, teacher driven approaches briefly. Maybe adding a little bit more about that would be helpful. Adding a bit about why people/teachers are hesitant to use VR may also set the stage.

Constructivist Learning in Immersive VR Settings and Generative AI

Virtual reality (VR) is often associated with gaming, or even immersive experiences at theme parks or aquariums rather than the go-to tool for educational environments to address specific learning challenges. However, in his TEDx talk *VR and AI in Education: The Future of Learning*, Kristen Tamm suggests that pairing VR devices like the Quest 2 with large language models like ChatGPT can transform education by creating immersive environments that address the global teacher shortage (Tamm, 2023). Tamm argues that VR allows students to take full control of their learning pace while staying completely focused and that the learning process is experienced in a highly immersive and sensory-rich 3D environment (Tamm, 2023). Tamm envisions how educational technologists of the future will use these technologies to fill

Commented [GG9]: This is a really nice transition sentence!

Commented [GG10]: "Tamm (2023) argues that.....3D environment."

instructional gaps in K-12 and presents the real-life example of a school's educational technologist who now fills the role as a geography teacher due to the impact of this technology (Tamm, 2023). There is impact that extends beyond the K-12 classroom and into language learning using VR. Research by Song et al. (2023) helps examine how VR learning experiences enhance language learning by using a constructivist framework and by what they call a "cognitive load framework" that balances experiential engagement with cognitive load limitations and show how the technology adapts to learners' needs specifically in the Duolingo VR and Rosetta Stone VR platforms. If language learning can be enhanced through VR, then educators and institutions also need to consider the various uses of VR in combination with AI that can provide hands-on learning experiences that will allow for risk-free practice in realistic settings and training that can be personalized to each learner.

Constructivism is not a theory, but an epistemology that explains the nature of knowledge, as it posits that learners actively create their own understanding (Schunk, 2020). As Cobb and Bowers (as cited in Schunk, 2020) state, "People construct knowledge based on their beliefs and experiences in situations, which differ from person to person" (p. 315). Given that knowledge is personal and subjective, and depends on context, we can see a natural connection to VR experiences, where immersive environments offer personalized and contextual learning. Dalgarno and Lee (2010) highlighted the benefits of 3-D virtual learning environments (VLEs) and established a theoretical base to support researchers and practitioners in the field of VR games and simulations and helped lay a groundwork for more appropriate applications of this technology. They conclude that when factual information is learned in the 3-D environment, "there will be a greater transfer of learning to the corresponding real environment... result[ing] in greater spacial learning than would occur when passively viewing an equivalent animation or

Commented [GG11]: What do you mean by risk-free? What are the normal risks? Like less pressure? Being more specific to just saying "will allow practice in..."may be helpful for the reader.

Commented [GG12]: Before jumping straight into this, you may want a sentence that connects back to your last paragraph: "Hands-on learning experiences can play an essential role in placing the student in charge of their learning, which is considered essential to constructivists" or something that touches briefly on what you just mentioned with VR and connects it back to constructivism

Commented [GG13]: This could actually be your topic sentence or a sentence like this! You would want to add "...we can see a natural connection between VR experiences and constructivism, where..." and then you could jump into the "constructivism is not a theory...."

video" (Dalgarno and Lee, 2010, p. 25). In their elaborated model of learning in 3-D VLEs, Dalgarno and Lee (2010) highlight "experiential learning, engagement, contextual learning, and collaborative learning" (p. 24) as the benefits to using VR in learning contexts, this well before the integration of AI into the environment. This research reflects the constructivist notion of situated cognition where learning is highly effective in the actual environment and context of which the transfer needs to occur (Schunk, 2020, p. 318). In more recent studies discussing generative AI (GenAI) aligning with constructivism, Salinas-Navarro et al. (2024) show how GenAI tools support the constructive learning process by promoting immersive experiences, personalized learning pathways, and dynamic problem-solving scenarios to further examine how tools like ChatGPT helps develop authentic assessment.

AI-Powered Adaptive Learning for Professional Training

The creation of adaptive learning technology (ALT) has marked a major advancement in education and training, offering a more personalized approach to learning compared to traditional classroom and e-learning methods (Gordon, 2020). His research shows that ALT "provides a true one-to-one and highly personalized artificial intelligence augmented ALT teaching assistant and a human teacher relationship with the learner that focuses on achieving mastery without traditional time constraints and subject barriers" (Gordon, 2020, p.2). Gordon, in his dissertation leans into the constructivist notion of discovery learning because of the ALT emphasis on self-regulation, even going as far as to suggest eliminating grade levels entirely. In more recent constructs of ALT using AI, Dutta et al. (2024) calls the AI powered versions "adaptive learning platforms" (ALPs) and have written a comparative analysis of four prominent platforms used in K-12 education; Carnegie Learning, DreamBox Learning, Smart Sparrow, and Knewton. This study provides educators in the modern context with insights and further defines

Commented [GG14]: Since this is plural you'll want to use call

the roles of teachers in these new environments. ALPs use AI and algorithms to "assess a student's understanding and then adjust the learning materials and activities accordingly" (Dutta et al., 2024, p.1). Moving away from K-12 and towards the professional realm there are studies of many kinds to support this. One study conducted on VR training for railway conductors show how these AI assisted VR platforms with ALP keep learners inside a 'flow channel' that Göbel and Wendel (2016) defined as a perfect balance between anxiety and boredom in relation to skill and challenge (Abbas et al., 2023). The connection to constructivism in this case comes from their reference to Fowler's (2015) notion of "task immersion" that is a primary contributor to experiential learning, and how the focus in this environment is placed on knowledge construction instead of reproduction (Fowler, 2015 as cited in Abbas et al., 2023, p. 3702). These studies along with others help prove the shift from behaviorist and cognitivist strategies to constructivist ones and show how the teaching profession will inevitably need to evolve into a more facilitative role compared to the past to align with these technologies.

Personalized Corporate Training Through VR and AI Learning Platforms

The evolution of uses for VR in the workplace has been prevalent from the late 1990s until the present, and there are various use cases highlighting the various iterations of this technology. In a comprehensive review of construction engineering training, Wang et al. (2018) cite the benefits of desktop-based VR, immersive VR, 3D game-based VR and augmented reality (AR) in many subtopics including architecture design, construction health and safety, equipment operation and structural analysis. They found that on-the-job training in these arenas are often impossible because on-site conditions are not revealed until work begins, so the VR training helps to address these practical problems in education and training of the employees in difficult

Commented [GG15]: "...professional realm, there...."

Commented [GG16]: What is the connection between this paragraph and your last paragraph? Is it about training? If yes, then maybe connect back to the shift in roles you just mentioned: "In order for teachers to take on a more facilitative role, they need to receive up-to-dat training on....."

Commented [GG17R16]: Or if this paragraph is more about how VR can not only provide effective education opportunities but can also be used to train professionals, you can highlight that as your connection. If neither of these are what you are trying to say, think about what the connection is and that can help you create a topic sentence to successfully transition your reader

hands-on contexts (Wang et al., 2018). Other studies show how AI has been introduced in robotics training to include machine learning (ML) and natural language processing (NLP). Peterson et al (n.d.) state that their "AI-assisted Adaptive Learning Systems (ALS)... are designed as a series of modular microlessons allowing learning content to be strategically rearranged based on learner performance" (p. 16) and thoroughly elaborate how they drew from constructivist and experiential learning theories in the process of developing the curriculum.

There are numerous companies in the marketplace currently training various skills in the workplace using AI assisted VR learning. The EdTech company Mursion is a leader in the field, and state on their website that simulations the preferred method for executives down to field workers to master human skills with their software, similar to how pilots train using simulators "giving leaders the opportunity to practice high-stakes interactions in emotionally charged situations without incurring the risk of doing harm to customers or colleagues" (Mursion, 2023). More companies like Strivr have already launched over two million training sessions and use extended reality (XR) and generative AI (GenAI) to produce soft skills training with a more natural and dynamic conversational training repertoire than ever seen before (Strivr, 2024). Strivr was created in 2015 at Stanford and offers VR training that covers nearly every industry and uses this technology to help streamline operational and procedural training like onboarding, compliance training, new technology training, process training, and inventory management (Strivr, 2024). These trainings often occur in the virtual metaverse where learners can train in a constructivist learning environment. Scholarly findings from Zhou et al. (2024) state the metaverse is a true representation of social constructivism because of how real-life global problems can be addressed from different perspectives in areas like climate geoengineering, water management, cybersecurity, and global competence. Research into the effects of VR

training in the metaverse by Saaed et al. (2024) describe the benefits of "real-time collaboration, enhanced practicality, alignment with technology training, real-time feedback analytics, and customizable learning environments [being] the positive aspects of metaverse-based training programs" (p. 12).

Constructivism and the Metaverse in VR Higher-ed Learning

VR training extends beyond corporate and human resource management training into the sphere of higher education, and the use of constructivism has been thoroughly examined in this context. The metaverse is more than a gaming platform or a place to buy virtual real estate. The benefits of using a constructivist approach to designing curriculum in the "edu-metaverse" has been researched by Sin et al. (2023), and they prove how immersive learning, visual literacy, and collaborative learning will be critical in this learning environment. Their research examines how the edu-metaverse will have "a knowledge hub for displaying multimedia content; avatars that facilitate multiuser discussion of educational content; an open platform for connecting immersive learning content, learning content creation; and social features for personalized learning" (p. 2), and have created a prototype called Knowledge-Cube VR with overall positive benefits on learners except for what they call "VR-fatigue." In a more recent study using this same platform, Jia et al. (2024) proves through research that in comparison to Zoom calls activities in the edu-metaverse like mind-mapping can be more effective for the constructivist strategy of collaborative learning. More studies regarding the metaverse indicate the benefits of active learning, collaboration and project-based learning for engineering students in Malaysia who use the metaverse to integrate real-world experiences into the learning environment (Sidhu et al., 2024). Engineering education is essentially being transformed via the metaverse by how it creates "a more immersive interactive experience, better visualization, reduced learning costs

and risks, not limited by time and space, prevents academic misconduct, [is] personalized, and promotes communication" (Sidhu et al., 2024, p. 15). There are benefits but also challenges that are associated with adopting this new technology in corporate and higher education sectors.

Challenges in Scaling VR and AI for Education

Adopting VR and AI assisted technology in the metaverse with adaptive learning has challenges including: a steep learning curve, high costs related to implementation and ongoing maintenance, pedagogical challenges, and ethical and privacy concerns (Sidhu et al., 2024, p. 15). Jia et al. (2024) found an issue with increased distractions located within the metaverse learning environment and this creates a dilution of attention, and "a noticeable uptick in off-task conversation" (p. 10). Also concerning is a disconnect between those with and without access, and this raises concerns about inclusion and equity in the technological space of the metaverse (Zhou et al., 2024). In addition to access concerns there are also issues with privacy and security for storing information in the metaverse that will need to be addressed from both a corporate human resource and educational perspective (Saaed et al., 2024). More examination uncovers opposition stemming from psychologists, lawyers, sociologists, philosophers, and journalists who question the social and psychological effects of participating in the metaverse including detachment from physical reality, addiction to virtual identities, the likely worsening of criminal and antisocial behavior, and fear that users will inevitably lose control of their behavioral data which can in turn be exploited by large companies (Dolata & Schwabe, 2023). My hypothesis is that some of these problems from the learner's perspective can be solved through the tenants of constructivism like active and reflective learning, where users engage critically after the VR experiences to foster a more self-awareness and responsibility to consider the consequences of their actions in this virtual environment.

Redefining Education Through Immersive Learning: The Future of VR and AI

When framed within a constructivist epistemology, the potential of virtual reality (VR) and artificial intelligence (AI) to revolutionize education is profound because of the emphasis on active, experiential learning (Marougkas et al., 2024). As discussed in this research paper, VR and AI technologies offer immersive experiences that allow learners to construct knowledge through personalized, adaptive learning environments like the one created in the Museum of Instructional Design (Glaser et al., 2024). Educational technologists can implement these tools in various settings from the tourism industry in hotels and museums to enhance the experience of travel (Doborjeh et al., 2022), to nursing homes for increased physical activity within the senior population (Bermúdez et al., 2023). I have shown throughout this paper that these technologies are becoming more ubiquitous and will be the future that Tamm (2023) discussed in his TEDx talk. Furthering this dialogue within a constructivist framework will help address current learning challenges and will also help educators create engaging and effective solutions to various problems in higher ed, healthcare and corporate training and other capacities (Jing et al., 2024; Tusher et al., 2024).

Commented [GG18]: If you haven't gone into depth about this example, you may not want to include it because your readers may not have any context

The research in this paper has helped prove how constructivist principles align with the various use cases of VR and AI and examines how these tools specifically provide learners with opportunities to practice various skills in risk-free yet very realistic settings similar to how project Preksha integrates automatic text visualization in a VR environment to learn Hindi through visual learning (Jain et al., 2020). The added layer of adaptive learning platforms to the AI assisted VR ensures that learning experiences are tailored to the individual needs of the student to help offer real-time feedback and promote deeper understanding of a myriad of topics (Gordon, 2020). While there are numerous benefits to AI assisted VR technologies, the

challenges for full scale implementation cannot be overlooked. Addressing these various obstacles will require ongoing evaluation and thoughtful implementation from leaders in learning design and technology. Looking towards the future, we can embrace the immersive and personalized possibilities of VR and AI within a constructivist framework and can collectively work towards a future where education is not only more engaging and effective, but also more inclusive and transformative.

References

Abbas, Y., Martinetti, A., Nizamis, K., Spoolder, S., & van Dongen, L. A. M. (2023). Ready, trainer ... one! Discovering the entanglement of adaptive learning with virtual reality in industrial training: A case study. *Interactive Learning Environments*, 31(6), 3698–3727. https://doi.org/10.1080/10494820.2021.1940215

Bartlett, F. C. (Frederic C. (1995). Remembering: a study in experimental and social psychology. Cambridge University Press.

Bermúdez i Badia, S. et al. (2023). Development and validation of a mixed reality exergaming platform for fitness training of older adults. In: Simeone, A., Weyers, B., Bialkova, S., Lindeman, R.W. (eds) *Everyday Virtual and Augmented Reality. Human–Computer Interaction Series.* Springer, Cham. https://doi.org/10.1007/978-3-031-05804-2_5

Dalgarno, B. and Lee, M.J.W. (2010), What are the learning affordances of 3-D virtual environments?. *British Journal of Educational Technology*, 41: 10-32. https://doi-org.ezproxy.lib.purdue.edu/10.1111/j.1467-8535.2009.01038.x

Doborjeh, Z., Hemmington, N., Doborjeh, M., & Kasabov, N. (2022). Artificial intelligence: A systematic review of methods and applications in hospitality and tourism. *International*

Journal of Contemporary Hospitality Management, 34(3), 1154–1176. https://doi.org/10.1108/IJCHM-06-2021-0767

Dolata, M., & Schwabe, G. (2023). What is the Metaverse and who seeks to define it? Mapping the site of social construction. *Journal of Information Technology*, *38*(3), 239–266. https://doi.org/10.1177/02683962231159927

Dutta, S., Ranjan, S., Mishra, S., Sharma, V., Hewage, P., & Iwendi, C. (2024). Enhancing educational adaptability: A review and analysis of AI-driven adaptive learning platforms. *2024 4th International Conference on Innovative Practices in Technology and Management (ICIPTM)*, 1–5. https://doi.org/10.1109/ICIPTM59628.2024.10563448

Fowler, C. (2015). Virtual reality and learning: Where is the pedagogy? *British Journal of Educational Technology*, 46(2), 412–422. https://doi.org/10.1111/bjet.12135

Glaser, N., Yang, M., Li, S. E., & Mendoza, K. R. (2024). The museum of instructional design: An examination of learner experiences & usability in a collaborative 3D virtual learning environment. *TechTrends*, 68(2), 338–357. https://doi.org/10.1007/s11528-024-00933-6

Göbel, S., & Wendel, V. (2016). Personalization and adaptation. In R. Dörner, S. Göbel, W. Effelsberg, & J. Wiemeyer (Eds.), Serious games: Foundations, concepts and practice (pp. 161–210). Springer International Publishing.

Gordon, K. W. (2020). A conceptual design for an adaptive learning technology implementation model. *ProQuest Dissertations & Theses*.

Hu, K., Wang, R., Zhao, S., Yin, E., & Wu, H. (2024). The association between social rewards and anxiety: Links from neurophysiological analysis in virtual reality and social

interaction game. *NeuroImage* (Orlando, Fla.), 299, 120846-. https://doi.org/10.1016/j.neuroimage.2024.120846

Jain, P., Bhavsar, R., Shaik, K., Kumar, A., Pawar, B. V., Darbari, H., & Bhavsar, V. C. (2020). Virtual reality: an aid as cognitive learning environment—a case study of Hindi language. *Virtual Reality: The Journal of the Virtual Reality Society*, 24(4), 771–781. https://doi.org/10.1007/s10055-020-00426-w

Jia, Y., Wang, X. E., Sin, Z. P. T., Li, C., Ng, P. H. F., Huang, X., Baciu, G., Cao, J., & Li, Q. (2024). Knowledge-graph-driven mind mapping for immersive collaborative learning: A pilot study in edu-metaverse. *IEEE Transactions on Learning Technologies*, *17*, 1834–1848. https://doi.org/10.1109/TLT.2024.3406638

Jing, Y., Wang, C., Chen, Z., Shen, S., & Shadiev, R. (2024). A bibliometric analysis of studies on technology-supported learning environments: Hot topics and frontier evolution. *Journal of Computer Assisted Learning*, 40(3), 1185–1200. https://doi.org/10.1111/jcal.12934

Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2024). How personalized and effective is immersive virtual reality in education? A systematic literature review for the last decade. *Multimedia Tools and Applications*, 83(6), 18185–18233. https://doi.org/10.1007/s11042-023-15986-7

Mursion. (2023, May 8). Empathetic leadership helps solve the human-skills shortage: *Mursion*. Virtual Reality Training Simulation Software by Mursion. https://www.mursion.com/blog/empathetic-leadership-human-skills-shortage/

Peterson, E., Bogosian, B., Tubella, J., & Vassigh, S. (n.d.). Teaching robotics with virtual reality: Developing curriculum for the 21st century workforce. In: *Advances in Human Factors in Training, Education, and Learning Sciences* (pp. 12–18). Springer International Publishing. https://doi.org/10.1007/978-3-030-80000-0_2

Saeed, A., Ali, A., & Ashfaq, S. (2024). Employees' training experience in a metaverse environment? Feedback analysis using structural topic modeling. *Technological Forecasting & Social Change, 208*, 123636-. https://doi.org/10.1016/j.techfore.2024.123636

Salinas-Navarro, D. E., Vilalta-Perdomo, E., Michel-Villarreal, R., & Montesinos, L. (2024). Using generative artificial intelligence tools to explain and enhance experiential learning for authentic assessment. *Education Sciences*, 14(1), 83-. https://doi.org/10.3390/educsci14010083

Schunk, D. H. (2020). Learning Theories: An Educational Perspective (8th ed.)

Sidhu, M. S., Mousakhani, S., Lee, C. K., & Sidhu, K. K. (2024). Educational impact of metaverse learning environment for engineering mechanics dynamics. *Computer Applications in Engineering Education, 32*(5). https://doi.org/10.1002/cae.22772

Sin, Z. P. T., Jia, Y., Wu, A. C. H., Zhao, I. D., Li, R. C., Ng, P. H. F., Huang, X., Baciu, G., Cao, J., & Li, Q. (2023). Towards an edu-metaverse of knowledge: Immersive exploration of university courses. *IEEE Transactions on Learning Technologies*, 1–14. https://doi.org/10.1109/TLT.2023.3290814

Song, C., Shin, S.-Y., & Shin, K.-S. (2023). Optimizing foreign language learning in virtual reality: A comprehensive theoretical framework based on constructivism and cognitive load theory (VR-CCL). Applied Sciences, 13(23), 12557-. https://doi.org/10.3390/app132312557

Strivr. (2024, March). Forbes lists Strivr among America's best startup employers in 2024. *Strivr Blog*. https://www.strivr.com/blog/forbes-recognized-strivr-americas-best-startup-employers-2024

Tamm, K. (2023, September 11). VR and AI in education: The future of learning | Kristen Tamm | TEDxTartuED. YouTube. https://www.youtube.com/watch?v=XGkWh4v1hCE

Tusher, H. M., Mallam, S., & Nazir, S. (2024). A Systematic review of virtual reality features for skill training. *Technology, Knowledge and Learning*, 29(2), 843–878. https://doi.org/10.1007/s10758-023-09713-2

Wang, P., Wu, P., Wang, J., Chi, H.-L., & Wang, X. (2018). A critical review of the use of virtual reality in construction engineering education and training. *International Journal of Environmental Research and Public Health*, 15(6), 1204-. https://doi.org/10.3390/ijerph15061204

Zhou, Q., Wang, B., & Mayer, I. (2024). Understanding the social construction of the metaverse with Q methodology. *Technological Forecasting & Social Change*, *208*, 123716-. https://doi.org/10.1016/j.techfore.2024.123716

Sidhu et al. (2024) describe this positive learning environment as part of "Education 5.0," highlighting how learners become skilled in complex problem-solving through VR constructivist activities. These activities include active learning, collaboration, and project-based learning. The study showcased Malaysian engineering students who used the metaverse to integrate real-world experiences into their education (Sidhu et al., 2024).

The research in this paper demonstrates how constructivist principles align with various uses of VR and AI, showing how these tools provide learners with opportunities to practice skills in highly realistic settings. An example of this is Project Preksha, which integrates automatic text visualization in a VR environment to facilitate Hindi learning through visual methods (Jain et al., 2020).

The addition of adaptive learning platforms to AI-assisted VR ensures that learning experiences are personalized to each student's needs, providing real-time feedback and promoting a deeper understanding of various topics (Gordon, 2020).

Looking ahead, we can embrace the immersive and personalized possibilities of VR and AI within a constructivist framework, working collectively towards a future where education becomes more engaging, effective, inclusive, and transformative.