Introduction:

When we consider the application of virtual reality (VR) experiences, we think gaming or an immersive ride at a theme park or aquarium, not a tool in education to help solve problems or gaps in learning. Kristen Tamm in his TedX talk *VR and AI in Education: The Future of Learning* proposes that VR experiences on devices like the Quest 2 paired up with large language models like ChatGPT can help immerse students in an educational environment that will help solve the teacher shortage around the world (Tamm, 2023). Tamm argues that students are 100% focused and in charge of their own learning pace while in this world and they "can feel the 3D immersive experience through their senses" (Tamm, 2023). Tamm shows how educational technologists in the future will be able to fill the gap of instruction at K-12 schools, and I believe there is also a need for VR and AI learning experiences to enhance skill-based learning in adult education and workplace environments. The most effective approach will be to design and implement VR experiences through a constructivist methodology by way of adaptive learning to revolutionize apprenticeship and skill-based learning. This combination allows for a personalized path to mastery by creating immersive learning experiences that adjust in real-time to the needs of the learner and makes certain that knowledge is constructed effectively through relevant, hands-on applications. From my experience at a large sailing school, I have noticed how the limited number of certified instructors is prohibitive of students being able to practice their skills, and learners become hesitant to chase their dreams out of fear of being in dangerous situations without an instructor or partner. Access to AI assisted VR technologies can make a positive impact in this arena and the workplace. Much of the research on AI and VR in education focuses on traditional learners (e.g., K-12 or college students). This paper will argue that these VR experiences can be adapted for non-traditional education like adult learners (e.g. sailing classes, martial arts classes, etc.), and professionals who are seeking continuing education (e.g. corporate training, healthcare education training, etc.). The adaptation and customization of AI-driven VR technologies will better serve non-traditional learners in these contexts, and by using adaptive learning with a constructivist framework, corporate training managers and instructional designers will be able to better address the diverse needs of learners in these groups. My paper will define constructivism and adaptive learning to help build an effective blueprint for integrating VR to help solve training problems.

Section 1: Defining Constructivism, Adaptive learning and AI-driven VR technologies

Constructivism is not a theory per say, but an epistemology which explains the nature of knowing because learners create their own learning (Schunk, 2020). Knowledge from the constructivist perspective is not formed from outside truths but formed inside oneself (Schunk, 2020). "People construct knowledge based on their beliefs and experiences in situations, which differs from person to person" (Cobb & Bowers as cited in Schunk, 2020, p. 315). So, if knowledge from this perspective is personal and subjective, and is dependent on contexts we can see a correlation towards VR experiences. (quote VR construct article)

Introduction: Transforming Education, The Power of VR and AI to Address Learning Challenges

When we think of virtual reality (VR), we often associate it with gaming or immersive experiences at theme parks or aquariums, rather than as a tool for education to address 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, experiencing the learning process in a highly immersive, sensory-rich 3D environment (Tamm, 2023).

Tamm envisions how future educational technologists will use these technologies to fill instructional gaps in K-12 schools like the example he gives citing a school's educational technologist will now be filling the role as geography teacher (Tamm, 2023). Research by Song et al. (2023) shows how VR learning experiences enhance language learning using a constructivist and cognitive load framework by balancing engagement with cognitive load and adapting to learner's needs specifically using Duolingo VR and Rosetta Stone VR (Song et al., 2023). If language learning can be enhanced through VR, then one should 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.

This paper will focus on how constructivism in learning environments using VR and AI is used for scenario-based learning experiences that simulate real-world situations in settings like healthcare and corporate training to mirror real challenges and create lasting impressions on learners that will transfer to the performance context. By developing tools that incorporate constructivism and adaptive learning platforms into the training, students will be able to learn by doing and build knowledge through experience while the system adapts to you, ensuring everyone gets the most effective level of support.

Constructivist Learning in Immersive VR Settings and Generative AI

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). From the constructivist perspective, knowledge is not derived from external truths but is formed internally by the learner (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 to help lay a groundwork

for discovering more appropriate applications of this technology (Dalgarno and Lee, 2010). 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 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 usage in learning contexts. This connection reflects the constructivist notion of situated cognition where learning has been proven to be highly effective in the actual environment and context of which the transfer needs to occur (Schunk, 2020, p. 318). In more recent studies regarding generative AI (GenAI) being aligned with constructivism, Salinas-Navarro et al. (2024) show how GenAI tools can support the constructive learning process by promoting immersive experiences, personalized learning pathways, and dynamic problem-solving scenarios further purporting how tools like ChatGPT can help develop authentic assessment (Salinas-Navarro et al., 2024). As we explore specific contexts, we can further see how adding a layer of adaptive learning to this equation can help redefine the future of learning with the possibility of combining them all.

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). 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) and lends itself to the constructivist notion of discovery learning because of its emphasis on self-regulation. More recently, Dutta et al. (2024) calls the AI powered versions of these, adaptive learning platforms (ALPs) and has written a comparative analysis of four prominent options used in K-12 education- Carnegie Learning, DreamBox Learning, Smart Sparrow, and Knewton- to help provide educators with insights and help define 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). In the professional realm there are studies on the effects of adaptive learning in VR training for railway conductors that "keep learners inside a 'flow channel' 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 contributes to experiential learning and the focus placed on knowledge construction instead of reproduction (Fowler, 2015 as cited in Abbas et al., 2023, p. 3702). Knowing this, we can look further at applications of VR in workplaces to help discover what problems have been solved using AI and VR in so we can set a course for the future and incorporate adaptive learning and create a cohesive learning environment for the future, where the teaching profession becomes transformed in to a more effective and facilitative role.

Applications of VR using Constructivism in Various Capacities

The evolution of uses for VR have been prevalent from the late 1990s until the present, and there are various use cases that highlight 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 and how these developments have benefited many topics including architecture design, construction health and safety, equipment operation and structural analysis. They found that on-the-job training is often not possible because on-site conditions are not revealed until work begins, and the VR training addresses practical problems in education and training (Wang et al., 2018). AI has been introduced in robotics training to include machine learning (ML) and natural language processing (NLP). In their work explaining how they teach robotics using these methods combined with VR, 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" (Peterson et al., n.d., p. 16), and cite that they drew from constructivist and experiential learning theories in the process of developing their curriculum.

Personalized Corporate Training Through VR Learning Platforms

There are numerous companies that are training various skills in the workplace using AI assisted VR learning. Mursion is a leader in the field and state on their website that simulations are going to be the preferred way for executives down to workers in the field to master human skills, similar to how pilots train using simulators, to "give 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). Companies like Strivr have already launched over two million training sessions as per their website 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 before (Strivr, 2024). Strivr was created in 2015 at Stanford and has VR training that covers every industry, and helps 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. 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 (Zhou et al., 2024). Research into the effects of VR training in the metaverse by Saaed et. al (2024) found that "real-time collaboration, enhanced practicality, alignment with technology training, real-time feedback analytics, and customizable learning environments are the positive aspects of metaverse-based training programs" (Saaed et al., 2024, p. 12).

Constructivism in VR higher-ed learning environments

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 benefits of using a constructivist approach to designing curriculum in the "edu-metaverse" has been researched by Sin et al. (2023) who state that immersive learning, visual literacy, and collaborative learning will be critical in this future 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" (Sin et al., 2023, 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 platform Jia et al. (2024) found that in comparison to Zoom calls, that activities in the edu-metaverse like mind-mapping can be more effective for collaborative learning, which is an important constructivist learning tool (Jia et al., 2024). Current studies also state 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). Education is essentially 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 and 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 like 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 that there are increased distractions within the metaverse learning environment which creates a dilution of attention and "a noticeable uptick in off-task conversation" (Jia et al., 2024, p. 10). There are also concerns that there will be a disconnect between those with and without access to these technologies, and this raises concerns about inclusion and equity in the technological space of the metaverse (Zhou et al., 2024). There are also privacy and security concerns for storing private data and information in the metaverse that need to be addressed from both a corporate human resource and educational perspective (Saaed et al., 2024). More examination uncovers more lines of criticism stemming from psychologists, lawyers, sociologists, philosophers, and journalists who discuss the social and psychological effects of participating in the metaverse such as detachment from physical reality and addiction to virtual identities, the likely worsening of criminal and antisocial behavior, and fear that users will inevitably lose control of their behavioral data and can be exploited by large companies (Dolata & Schwabe, 2023). Perhaps these problems can be addressed through the tenants of constructivism like active and reflective learning, where users will engage critically after the VR experience to perhaps foster a deeper self-awareness and responsibility and consider the consequences of their actions in this virtual environment.

Conclusion: 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 Tamm (2023) discussed in his TEDx talk. Furthering this dialogue 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 (Tusher et al., 2024) (Jing et al., 2024).

My research has helped prove how constructivist principles align with the various use cases of VR and AI and shows how these tools provide learners with opportunities to practice various skills in risk-free yet very realistic settings like how project Preksha integrated automatic text visualization in a VR environment to learn Hindi through visual learning (Jain et al., 2020). The added layer of adaptive learning platforms will ensure that learning experiences are tailored to the individual needs of the learner 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

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*.

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