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REVIEW PAPER

Extended Reality Vocational Training's Ability to Improve Soft Skills Development and Increase Equity in the Workforce

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Abstract

With the rise of the metaverse, extended reality (XR), which includes virtual, augmented, and mixed reality, has emerged as a key alternative education medium alongside more traditional online and onsite approaches. The onset of COVID-19 accelerated the efforts of private education companies in this sector to explore enhanced education opportunities in vocational training. Companies that produce immersive learning platforms integrate partners, content creators, and customers, focusing on the future by supporting soft skills. Immersive learning has helped a substantial number of workers to use XR learning methods to acquire knowledge faster, measure and validate their skills, and find upward mobility in the workforce through improved, on-demand accessibility options. This article examines an XR development plan through a diffusion of innovation framework coupled with social capital theory. A literature review reveals organizations' ability to capitalize on soft skills development while expanding global accessibility options for adult learners to improve learning equity opportunities.

Keywords: immersive learning, extended reality, virtual reality, vocational training, soft skills, adult learning

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1. Introduction

This literature review elucidates the diffusion of extended reality (XR) training to enhance vocational soft skills in the workforce by analyzing the innovation adoption process in select contexts. It explores extended reality development through Rogers' [1] diffusion of innovations framework coupled with social capital theory outlined by Frank, Zhao, and Borman [2]. The adoption of an innovation is affected by four key factors. These elements include actual change, the communication process, the time period of the adoption process, and the related social system [1, 3]. This study's focus is to review the effectiveness of XR learning methods in enhancing workers' soft skills and their ability to improve education equity by expanding global accessibility options for adult learners. This study addresses the following research questions:

RQ1: How can XR learning methods impact adult learner's soft skills and equitable educational options globally?

RQ2: To what extent did social capital influence the adoption of XR learning methods in the studied contexts?

1.1. What are XR learning methods and why are they used?

The implementation of digital, online, and XR learning methods has dramatically increased over the past decade. In particular, due to the COVID-19 pandemic, many schools, educational organizations, and businesses were forced to adapt rapidly to at-home learning needs to provide services to their homebound students. While digital and online learning approaches have demonstrated benefits, recent studies have highlighted immersive learning approaches, such as XR learning methods, as potential game changers in education. One can currently define the ever-expanding umbrella of XR learning methods as virtual, augmented, and mixed-reality educational approaches. These methods support the delivery of educational and training course materials through interactive computer simulations in immersive environments, which can sense positioning and responses, and provide feedback [4, 5]. Standard features include an immersive learning environment facilitated by essential hardware (e.g., Meta Quest 2 [6], HP Reverb G2 [7], Valve Index [8], Sony Playstation VR [9], HTC VIVE Pro 2 [10], etc.) and online learning modules. These modules facilitate individually-paced learning through lessons incorporated into a learning program with instructional objectives and a data analytics system, which assesses student progress and development, such as Talespin's immersive soft skills programs focused on conflict resolution, cognitive bias, and active listening and inquiry [11].

Regarding XR learning methods, immersion involves the quality of experience, mental absorption, and perceptual and cognitive engagement a simulation offers in a digitally-generated space [5, 12, 13]. Burdea and Coiffet [14] maintained the three most important properties of immersive technologies like VR are the 3Is, imagination, immersion, and interaction. Immersion through simulated learning, such as XR learning methods, can increase engagement, memorization, skills acquisition, and knowledge transfer through situational understanding [12, 15]. These immersive learning approaches and hardware are beginning to evolve how organizations offer training and educational opportunities to their students and employees, providing accessible on-demand learning as a substitute for limited face-to-face alternatives. These learning experiences offer exposure to challenging situations in safe, controlled environments and simulate complex, detailed interpersonal engagements and situations, allowing users to gain and improve skills while applying them in real-life scenarios [16–19]. Multiple studies noted K-12 and higher education VR-based instructions were effective in improving learning gains [12, 20]. As organizations evolve with changing needs for the future of work, employers identified soft skills as an area of deficiency in potential employees and workforce-entering graduates [21–23]. Few essential soft skills and related competencies include communication, critical thinking, intercultural competency, leadership, teamwork, and time management. Employers often consider these skills more critical than undergraduate majors because today's workplaces need critical perspectives and diverse viewpoints [22] to face and solve real-world problems [24].

While multiple studies demonstrated the effectiveness, satisfaction, and quality of XR learning methods [16], wide adoption in educational organizations is still a work in progress, requiring further investigation of XR development and adoption process. A 2020 TechRepublic survey of tech executives noted that 56% of businesses implemented mobile AR/VR technology, and another 35% considered doing so [25]. However, only 26% used it for training and professional learning purposes. Though multiple XR hardware options exist, some of the most popular models suffer from key drawbacks, including high cost, mediocre controls, space and tether cable requirements, and low-quality resolution [26]. Additionally, XR-based learning design and development is often guided by intuitive and common-sense approaches rather than a well-researched educational affordance analysis, potentially impacting the learning effectiveness and outcomes [12, 27, 28]. Failed XR learning adoption cases can relate to users' technology literacy deficiencies, including lack of VR experience, need for technical support and comprehensive onboarding [29], misconceptions of learners' benefits and effectiveness, especially for specific industries such as healthcare and medicine [17].

2. *Theoretical framework*

With the growing global output and adoption of XR learning methods, it is critical to analyze the theoretical frameworks which affect and can potentially support this process. It is vital to assess the impact of technology diffusion processes and the potential for social networks to impact the adoption process for XR learning methods. This literature review analyzes an XR development plan through the theoretical lens of a diffusion of innovations framework coupled with social capital theory. This framework depicts organizations' potential to capitalize on soft skills development while expanding global accessibility options for adult learners and therefore improving learning equity. In his theory, diffusion of innovations, Rogers [1] highlighted how an innovation was adopted and communicated across organizations over time by various stakeholders. However, unlike the application of

Rogers' theory in highly hierarchical structures, educational organizations involve more complex ecological decision-making systems and social networks of influence [2]. Social influence within organizations engaged in learning endeavors is crucial to successful adoption, specifically when considering potential benefits, social pressures, and organizational objectives. Social capital theory emphasizes the expertise and resources accessible within social networks and their capacity to achieve change [30–32].

In organizations, particularly those tied to education and training endeavors, social systems connect team members and faculty to the failure and success of its efforts, such as innovation adoption [2]. As Frank and colleagues [2] note, champions and change agents, key vanguards of organizational growth and development, exert social pressure through these shared systems, linking macro-level decision-making with micro-level individual action. Champions are often innovators and early adopters who improve credibility and persuasion among other stakeholders through social engagement by demonstrating relative advantage, absence of complexity, and observability [1, 33]. Change agents facilitate effective change to an existing system through social capital and influence in a shared network [2]. However, different organizations have varying social strata and influence within their systems. Therefore, following Rogers' diffusion of innovations pattern, successful adoption plays out individually in each context through social exchange, relationships, and community engagement [2]. Despite these differences, through the theoretical framework of diffusion of innovations coupled with social capital theory, it is possible to identify an approach for successful XR learning methods adoption, which can offer beneficial macro- and micro-level organizational change.

The researcher employed a comparative framework proposed in a previous study on the diffusion of learning management systems innovations in higher education context [34]. This framework highlighted four critical thematic areas aligned with Rogers' [1] adoption process, (1) the motivation to adopt, (2) the decision to adopt, (3) the adopter categories, and (4) the implications of the adoption process as noted in Table 1 [34]. These four areas connect directly to the contextual social environments and the impact of social capital and influence on the diffusion process. The researcher used these critical thematic areas to structure the literature review of the analyzed virtual reality (VR) learning methods articles.

3. Factors related to XR learning methods adoption

The adoption of innovations occurs differently in each organization, and various aspects impact how it transpires. Rogers describes five essential characteristics that determine the acceptance of an innovation (e.g., XR learning methods, etc.) within a given context. These factors include perceived or relative advantage over previous

Table 1. Thematic categories.

Category	Description
Motivation to adopt	Motivation to adopt involved a review of why the context was influenced to adopt the particular learning management systems (LMSs) in question, focusing on a variety of factors. Five attributes of an innovation that affect adoption which were reviewed related to Rogers' [1] diffusion of innovations theory included (1) relative advantage, (2) compatibility, (3) complexity, (4) trialability, and (5) observability.
Decision to adopt	Decision to adopt was an analysis reflecting on where the decision to employ the selected LMSs emerged within the context and how that decision was diffused through the contextual social environment.
Adopter categories	Adopter categories involved an examination related to Rogers' [1] adopter categories associated with the diffusion of an innovation, including (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards.
Implications of the adoption process	Implications of the adoption process related to what discernible outcomes, the adoption of the LMSs had on the context.

Note. From "Social capital and the diffusion of learning management systems: a case study", by B. Boland [34].

ideas, compatibility with existing values and practices, simplicity and ease of use, trialability, and observable results [1]. The author highlights how meeting key stakeholder needs is paramount when introducing innovations, determining the fundamental success of the endeavor. Social engagement and networks represent essential conduits for innovation diffusion, emphasizing the pivotal role social capital and influence play regarding innovation and new technology acceptance and endorsement. Five populations directly impact innovation adoption: innovators, early adopters, early majority, late majority, and laggards [1]. The relationships between these divergent yet connected and symbiotic groups pinpoint the critical interaction point of diffusion of innovations and social capital theory, highlighting a vital alignment when examining innovation adoption. Both Rogers [1] and Frank and colleagues [2] assert the essential role social network systems play in the innovation adoption process. They also identify a critical investigatory point for researchers to analyze to understand organizations' abilities to capitalize on XR learning methods related to soft skills development. Effective application utilizing a comprehensive understanding of social influence and diffusion processes would ensure successful adoption and expand global accessibility options for adult learners to improve learning equity opportunities. In the following sections, a literature review examines the adoption process of XR learning methods in several contexts through the thematic categories of motivation to adopt, the decision to adopt, adopter categories, and implications of the adoption process.

3.1. Motivation to adopt

Motivation to adopt new technologies and learning methods at organizations can vary but often focus on several key aspects, including business value, cost, learning speed, overall quality and learning value, and exploring new technologies [16]. A joint study led by Price Waterhouse Coopers (PwC) [35] on Talespin [36], an XR vocational training firm, and its VR learning methods emerged from interest and inspiration generated while viewing a Talespin VR demonstration in 2018 at Boston's Emerging Technology conference. The PwC team viewed the learner demo as "an immersive, engaging and emotional experience" and a "game changer" [16, p. 10–11]. PwC sought to investigate if VR soft-skills training was more effective regarding learning and cost than traditional methods (i.e., classroom, e-learning). The motivation to adopt and trial within PwC occurred as a top-down, authoritative organizational decision. It related to the relative advantage the new VR learning could provide to the leadership, its compatibility within the organization, and the potential questions trialability could answer and implications it could have for PWC and broader organizational training.

In another study, Palmas, Cichor *et al.* [18] examined the effectiveness of VR public speaking training with 44 participants. The primary decision to adopt the technology in the study related to positive benefits attributed to VR applications related to presence, noted as the concept of 'being there' and having the opportunity to experience learning corresponding to real-world scenarios [18, 37, 38].

During COVID-19's first six months, Young and Aquilina [39] detailed how Virti, a United Kingdom (UK) based training and development company, conducted a feasibility trial of on-demand VR learning support to National Health Service (NHS) organizations and fifty healthcare professionals across the UK and United States (US). The decision to adopt this test program rapidly related to the need for training hundreds of thousands of healthcare workers, with face-to-face options unable to meet the demand. VR learning methods delivered via headsets and smartphones provided the relative advantage of rapid scalability at a low cost. They also matched the compatibility and complexity of the large-scale crisis, on-demand needs. The adoption also offered product trialability before wide-scale adoption and observability of potential key benefits, barriers, and needs.

Ke and colleagues [12] adopted VR-based learning to investigate the simulated environment's affordances, benefits, and constraints regarding providing teaching training for university graduate teaching assistants related to goal-based scenarios and learning support design. The study engaged seventeen graduate teaching assistant participants in a multiple-case study with OpenSimulator. This open-source virtual environment platform provided a simulation-based teaching training program focused on their engagement in a virtual classroom with interactive, non-player characters (NPCs). They specifically examined the design aspects that enhance and improve the educational affordance of an intentionally-designed VR learning environment with university students. The motivation to adopt related to relative advantage for the graduate assistants, compatibility with a higher education learning environment, the complexity of training soft skills related to teaching, and trialability of a new technology learning method.

3.2. Decision to adopt

Rogers [1] detailed three types of decisions associated with the decision to adopt an innovation: (1) it is "optional," and an individual may adopt or reject it, (2) the collective group decides to adopt or reject, or (3) an authority figure or body makes the decision for the group. At PwC, Talespin's VR learning methods were first employed in 2020 for ten months as a top-down, authority-innovation decision. It was associated with trialing and exploring the learning and cost benefits of training with the new technology with internal staff compared to more traditional classroom and e-learning approaches [16].

Like PwC's study, Palmas and colleagues [18] employed a top-down researcher decision to test the public speaking VR learning approach but only implemented it for a single short training session. As participants were selected from multiple contexts, no clear decision to adopt was identifiable for particular organizations. However, participants noted a high barrier to social diffusion in individual contexts due to management resistance.

Young and Aquilina [39] described a similar top-down authority body decision process in their study. Virti needed to align with funding from NHS in the UK and top health providers in the US to implement the VR healthcare learning trial. Participants were randomly selected for the control and intervention groups, giving them zero insight into the adoption decision process.

Following a pattern with the other detailed studies, Ke and colleagues [12] also noted a top-down authority body decision regarding the adoption process in their research, acting as the sole deciders for its implementation. The authors recruited seventeen graduate teaching participant volunteers from various disciplines, including computer science, chemistry, physics, biology, psychology, philosophy, and modern language.

3.3. Adopter categories

Eckert and Mower [16] did not specifically identify the involvement of the adopter categories at PwC. However, the PwC Emerging Technology team noted its lack of knowledge regarding the psychology and science behind the novel learning technology. As a result, it partnered with PwC's Learning and Development group to investigate two key research questions. Therefore, the study involved innovators trialing a new organizational training potential tool.

The public speaking VR training study by Palmas and colleagues [18] also did not explicitly identify adopter categories. However, as many participants highlighted its innovative nature compared to their rather conservative-minded organizations regarding training, it most likely involved the innovator adopter category.

Following a trend with previous articles and due to its novel nature, Young and Aquilina [39] also did not identify specific adopter categories. However, based on the trialability factor of the VR healthcare training, it once again described the innovator adopter category, with the idea that successful implementation would diffuse through social influence from top NHS and US provider officials and participating administrators, doctors, and healthcare professionals.

Recruits for the VR learning affordance study with Ke and colleagues [12] were graduate student volunteers across multiple disciplines actively engaged in teaching other university students. Considering the voluntary aspect of the recruitment, the student also describes the innovator category, with participants interested in engaging and learning through a new technology method.

3.4. Implications of the adoption process

Several studies highlighted key implications for the adoption process. In the PwC study on Talespin, Eckert and Mower [16] highlighted several measurable outcomes of the VR learning experiment. The authors noted Talespin's VR training was more efficient at training soft skills concepts and was more cost-effective than classroom and e-learning approaches. The study also highlighted that participants were 275% more confident about concepts learned, four times more focused than e-learners, learned four times faster than in the classroom, and possessed 3.75 times stronger emotional connection to their learning [16]. The authors maintained eight key considerations and insights for the VR learning method adoption process: (1) onboard new VR learners effectively, (2) create compelling learning content for VR, (3) collaborate cross-functionally, (4) reinforce learning through debriefing, (5) create templates to support scaling, (6) include VR as a part of a blended learning curriculum, (7) invest in the learning modality suited to the learning objective, and (8) VR is ready to scale in the enterprise.

Palmas and colleagues [18] noted that while participants found the training engaging and 80% highlighted it as beneficial for their organizations, the majority felt multiple sessions versus a single session was required to be more effective for learning. A critical implication and potential barrier related to the adoption of VR learning methods highlighted by the participants related to the viewpoints and acceptance of their organizations. Participants described that the approach could not be effectively implemented in their organizations due to “conservative decision makers and skepticism” regarding the technology [18, p. 369].

In their literature review examining gamification, serious games, simulations, and immersive learning environments in knowledge management initiatives, Ahmed and Sutton [40] described higher education and organizational training as experiencing significant disruption in today’s workforce to meet 21st century challenges. To meet the demands of this disruption, the authors maintained teaching and learning initiatives need to integrate more experiential learning, which gamification, immersive learning, serious games, and simulations provide (2017).

Immersive VR training methods can also provide large-scale adaptive training quickly [39]. The authors highlighted multiple additional potential use cases in health and social care beyond emergency COVID-19 protocols, “including accelerating care certification, refresher and re-certification training, and more soft skill based modalities including but not limited to: roles and responsibilities; whistleblowing; equality, diversity and person centred values; telephone support and communication; pain and discomfort; infection prevention and control; food safety; fluids and hydration; health and safety and stress management” [39, p. 142]. The study concluded that immersive learning approaches could offer learner growth coupled with convenient, on-demand access to a wide variety of learning opportunities along with data insights to improve reflective feedback and maximize performance [39]. In addition, financial data revealed significant savings regarding training costs and return on investment for VR immersive training.

Ke and colleagues [12] maintained that a well-designed VR-based learning environment fosters participants’ effectiveness in interactive teaching and demonstrative instruction. They also claimed it trains them to identify and attend to students’ actions and reactions during the instruction process, allowing them to provide more effective support. While there is no agreed upon definition of a ‘well-designed’ VR-based learning environment, the author suggests the critical 3Es — engagement through immersion, elevation of instructional interaction, and effective support. As Robert Sternbert noted, “the major factor in whether people achieve expertise is not a fixed prior ability but purposeful engagement” [41, p. 14].

In XR, purposeful engagement involves effective immersion in a simulated environment, which offers a high-quality experience, mental absorption, and perceptual and cognitive engagement [5, 12, 13]. Elevation of instructional interaction points to complex interactions with the virtual environments and NPCs, allowing for conceptual absorption of effective practices. Finally, effective support notes the need for onboarding, ongoing training, and technical support [29] to ensure an efficient learning process. Additionally, Ke and colleagues [12] described the graduate participants demonstrating a more precise understanding and application of the embedded teaching knowledge by leveraging the situated learning in the simulated environment [12]. It also maintained evidence of the effectiveness of engagement with NPCs. However, multi-way interactions and multiple graphical presentations in the VR environment limited participant interaction, and the lack of reciprocal engagement from limited NPCs reduced the cognitive impact of the teaching scenarios. The study highlighted that physical reality maintained advantages over the virtual environment due to the limited functional intelligence of NPCs, as added intelligence and engagement could overwhelm real-time processing constraints. The authors recommended a potential design strategy to overcome this challenge. This approach involved integrating "a choice-based interaction interface that enables the user to interact with virtual agents through semi-structured (e.g., multiple-choice) responses during a simulated scenario, thus reducing the need for text or nonverbal action processing" [12]. Finally, the authors noted the simulated virtual environment offered an absence of maneuverability and complex interactions between the users and the environment compared to a real classroom.

3.5. Adoption process of XR learning methods

Several studies analyzed the adoption process of XR learning methods within different contexts [12, 16, 18, 39, 40]. These studies described various reasons connected to Rogers' [1] diffusion of innovation theory that adopters initially embrace an innovation. As Rogers highlighted, adopters fall into five different categories: (a) innovators, (b) early adopters, (c) early majority, (d) late majority, and (e) laggards. In all studies reviewed, adopters fell primarily into the innovator category with little long-term diffusion described due to study lengths and the relative novelty of the technology. Rogers [1] detailed the adoption process flow aligning with a standard bell curve as more individuals in a social system embrace its use. Rogers also maintained adoption followed five key stages, including knowledge, persuasion, decision, implementation, and confirmation, starting with the initial introduction and use. The studies reviewed only showcased the knowledge and persuasion stages, as long-term adoption was not examined. These initial studies highlighted fundamental knowledge and persuasion points that social champions within their organizations could use to engage others to implement XR learning methods.

Due to the short longevity of the studies and technological novelty, social pressure could not be adequately analyzed. However, the very investigation and introduction of the novel technology for examination highlighted the engagement of innovators and potential champions to promote its use. In this case, researchers filled the role of introductory change agent, with the beneficial results potentially working to further the early adoption process to disseminate the XR learning innovations amongst other organizational trainers, learners, and leaders. However, further investigation is required to determine if this had an actual impact. This description aligns with Frank and colleagues' [2] social capital-infused theoretical diffusion model within organizations. This model identifies change agents as essential for the influential and practical introduction and exchange of ideas within the social network of a given organization. In this case, the researchers acted as the change agents within the community, with further champions required to facilitate the diffusion process effectively. Social exchange through a network of influential colleagues, trainers, and organizational leaders is crucial for rapidly adopting new technology. This aspect requires further, long-term analysis in future studies focusing on the comprehensive adoption process contexts implementing XR learning methods.

4. Conclusion

The contexts examined in this literature review maintained a substantial alignment with Rogers' [1] diffusion of innovations theory. However, they were not able to confirm the relevance of Frank and colleagues' [2] social capital theory related to XR learning methods due to the lack of longevity within the contexts examined. Top-down, authority-innovation directives determined the initial adoption processes in all of the contexts, either from the researchers or researchers in collaboration with supporting organizations. In each case, the researchers acted as change agents for the organizations, introducing the XR learning method innovations to the organizational networks and initiating the early stages of the adoption process. As innovators, the researchers provided key persuasive evidence to the organizations of the potential benefits of employing XR learning methods. Absence of long-term data on the adoption process and social capital impact made it impossible to draw definitive conclusions linking the two theories to XR learning methods and their integration in new contexts.

5. Implications

Several implications emerged from the results of the studies analyzed. XR learning methods can potentially disrupt and revolutionize education through a host of learning and scalability benefits [16, 18, 39, 40]. The ability to provide convenient, on-demand, and immersive online training to any learners in need can address global equity issues in education and workforce soft skills deficiencies. Economically speaking, XR learning methods offer drastic professional learning and development savings to organizations regarding training costs and return on investment on employee upskilling [39]. Though there can be an initial investment cost in the hardware if not employing mobile device VR/AR learning, these economic benefits can still be realized through long-term, widespread, reusable implementation, allowing for widespread equitable use.

Despite these financial savings, it is critical for content creators and trainers to consistently update their training and teaching materials due to the rapid development of new hardware, software, and XR learning methods and applications [4]. Open-source XR learning platforms with large communities and modular design adaptation capabilities offer a strong potential for learning growth and extension through community engagement [4]. These communities can dramatically enhance VR adaptations to meet local needs across the global learning nexus. It is also critical for content creators to focus on crucial design facets when creating a VR learning experience. These aspects include the primary learning action/objective, the mode of action and engagement, the environment and learning process tools and rules, objects and NPCs to interact with during the activity, an environmental narrative, and environment-situated learner support [12].

Additionally, though recent dramatic advancements have occurred in XR learning hardware, software, and applications, real-time process constraints still limit XR environments regarding engagement capacity with the environment for users, visual realism, graphical support, and NPC artificial intelligence [12]. Further research is required regarding the benefits and drawbacks, efficient design solutions, and cognitive interactivity and immersion of XR-based training and professional learning when future hardware overcomes real-time processing constraints and eventually makes the virtual environments indistinguishable from reality.

The most significant challenge facing a comprehensive analysis of the adoption process and the impact of social capital on VR learning methods is the absence of long-term data. As the technology remains new and evolving, a lack of data is a constraint to draw definitive, cogent conclusions describing the complete adoption process across an organization and the full impact of social pressure and influence within a system to drive this innovation adoption. Further study is suggested in multiple contexts regarding these aspects.

Conflict of interest

The author declares no conflict of interest.

Appendices and Nomenclature

XR	Extended reality
VR	Virtual reality
UK	United Kingdom
US	United States
NHS	National Health Service
NPC	Non-player character
LMSs	Learning management systems

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