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FROM HR TO XR: INTEGRATING ARTIFICIAL INTELLIGENCE AND EXTENDED REALITY FOR FUTURE WORKPLACE LEARNING

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Abstract

This study investigates the transformative relationship between Artificial Intelligence (AI) and Extended Reality (XR) technologies and their multifaceted impact on workplace learning, specifically focusing on employee engagement, skill acquisition, and knowledge retention. The primary aim was to examine how adaptive, immersive learning environments influence cognitive, technical, and crucial soft skill outcomes. Utilizing a quantitative research design, data was gathered through structured observations, detailed surveys, and objective performance metrics from participants engaged in an AI-XR enhanced training program. Subsequent analysis confirmed a statistically significant positive relationship between these integrated training programs and superior learning outcomes. The findings further revealed that the AI-XR program not only streamlined procedural practices and technical proficiency but also profoundly influenced learners' emotional and behavioural engagement by fostering a sense of presence and interactive involvement. This underscores the critical importance of intentional instructional design elements, such as high scenario realism, advanced simulation techniques, and responsive AI-driven personalization, for maximizing training effectiveness. These elements directly enhance employee engagement and satisfaction, which are key drivers of overall organizational performance. The research substantiates the substantial potential of AI-XR integration to elevate employee performance through dynamic, scalable, and adaptable technology-driven learning solutions that simultaneously address hard and soft skill gaps. Practical implications emphasize the necessity for a phased, strategic implementation of such programs, ensuring alignment with core pedagogical principles and incorporating mechanisms for continuous evaluation and iterative improvement. Proposed future research directions identify the need for longitudinal studies to assess skill durability, cross-comparative analyses across diverse industry sectors, and deeper investigation into the integration of AI-XR platforms with advanced learning analytics for predictive insights

Keywords: AI, Engagement, Immersive Learning, Skill Acquisition, Workplace Learning, XR

Introduction

The combination of Artificial Intelligence (AI) and Extended Reality (XR) was becoming a disruptive change in workplace learning and reconfiguring the conventional Human Resource Development (HRD) paradigms. Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) were becoming increasingly popular with organizations as ways of providing interactive and simulation-based learning, and AI applications like adaptive learning, recommendation algorithms, and intelligent tutoring systems were becoming more personalized and decision-supporting (Jongbloed et al., 2024; Lampropoulos, 2025). The integration of these technologies promised to enhance the level of scalability, decreased training duration, and enhanced meeting organizational skills demands (Lin et al., 2023; Radianti et al., 2020). With a shift of industries towards automation and digitalization, AI-XR systems provided personalised and data-driven learning ecosystems that could assist employees in the fast-changing workplace (Maathuis et al., 2025; Barbu & Băjenaru, 2025).

Studies had always showed that XR settings were better than the real world with respect to procedural learning, fewer errors, and stronger memory, especially in highly complex fields like healthcare, aviation and engineering (Jongbloed et al., 2024; Radianti et al., 2020). Meanwhile, AI-based learning analytics and smart tutoring systems provided the granular observation of the performance of learners and allowed offering them individual scaffolding and timely corrective feedback (Lin et al., 2023; Kumar et al., 2022). It was argued by scholars that applying XR sensory experience with AI adaptive intelligence would result in synergistic advantages, which will produce a system of learning that is both experiential and cognitive optimized (Lampropoulos, 2025; Maathuis et al., 2025). These changes were in line with the general trends at workplaces around the major focus of ongoing learning, providing upskilling, and being digitally competitive, and are part of the competitive advantage (Chen et al., 2023; Borsci et al., 2022).

Although AI-XR learning systems have potential, they encountered a few challenges that did not allow them to be used widely. Technological constraints, moral matters, and the organizational preparedness were a continued concern in all industry sectors (Barbu & Baja nuara, 2025; Maathuis et al., 2025). Hardware costs, motion sickness, AI explainability, data privacy, and instructional design complexity were some of the factors that led to issues when rolling them out (Radianti et al., 2020; Rauschnabel et al., 2022). Further, most available research used small samples, laboratory conditions, or short-term studies, which reduce the applicability of the results (Jongbloed et al., 2024; Chen et al., 2023). That is why it was necessary to conduct extensive research on the pedagogical processes, organizational aspects, and situational elements that determine the effectiveness of AI-XR-based workplace training.

Considering these loopholes, the current research examined how AI and XR were introduced into learning systems in the workplace and how they earned training efficacy, participation, and application in the field. It has reviewed the empirical research on the performance gains, experience of learners and organizational results of recent studies in various industries (Lampropoulos, 2025; Lin et al., 2023; Maathuis et al., 2025). The study aimed to offer a conceptual comprehension of the possibilities and limitations related to the adoption of AI-XR as a part of HRD by synthesizing interdisciplinary implicates of education, cognitive science, and human-computer interaction to create a holistic understanding of the concept. The paper was also placed to guide HR practitioners, instructional designers and organizational leaders to make evidence-based decisions about new learning technologies (Borsci et al., 2022; Chen et al., 2023; Radianti et al., 2020).

Research Background

The technologies of the Extended Reality had already achieved a significant spread in learning in the workplace as they provided an opportunity to implement experiential and risk-free training conditions and provide the context. It was stated that XR simulations enhanced procedural accuracy, psychomotor, and situational awareness in surgery, manufacturing, logistics, and emergency response (Jongbloed et al., 2024; Radianti et al., 2020). Workers were able to practice demanding challenges reduced disturbance to actual activities and this improved confidence and autonomy through the creation of immersive learning environments (Rauschnabel et al., 2022; Borsci et al., 2022). Moreover, XR-based education systems have been demonstrated to promote learning via reduced cognitive overload with the help of visual, auditory, and haptic feedback facilitating multisensory learning (Jongbloed et al., 2024; Radianti et al., 2020).

At the same time, due to fast progress in AI (especially in the adaptive learning, natural language processing, and affective computing), the opportunities of digital learning systems were growing. Intelligent tutoring systems supported by AI contributed to the provision of personalized instructions, analytics with real-time performance tracking, and automated assessment adapting to the performance of individual learners (Lin et al., 2023; Kumar et al., 2022). The learning difficulties could be accurately predicted with the help of machine-learning models, as a result, the timely help was provided, and gaps in skills were minimized (Chen et al., 2023; Borsci et al., 2022). The AI-based analytics also provided insights to organizations that cover training effectiveness, skill identifies, and skills/workforce growth paths, which reinforced the strategic HR decision making (Maathuis et al., 2025; Lampropoulos, 2025).

New studies were done on integrating AI and XR to form hybrid learning environments that can enable more receptive training. Multimodal feedback, adaptive practise activities and expert performance modelling were offered by the use of AI agents in VR simulation (Lampropoulos, 2025; Maathuis et al., 2025). These hybrid systems were found to improve engagement and problem-solving better and help the learners feel more autonomous than XR applications when used alone (Chen et al., 2023; Kumar et al., 2022). Moreover, explainable AI (XAI) systems of deep training obtained more recognition as a necessary tool to improve user trust and transparency in making decisions in the context of immersive training (Maathuis et al., 2025; Rauschnabel et al., 2022).

These promising developments notwithstanding, there were a few obstacles to the institutionalization of AI-XR training systems. A significant number of organizations had challenges with infrastructure demands, integration with the existing LMS systems, as well as the necessity to apply specialized instructional design skills (Borsci et al., 2022; Barbu and Băjenaru, 2025). Biometric information, sensor surveillance, and artificial intelligence-powered decision-making raised other ethical issues that presented greater challenges to HR administration and decision-compliance constructs (Maathuis et al., 2025; Rauschnabel et al., 2022). In addition, cross-cultural diversity, employee digital maturity, and price factors were also still important factors according to the success of the adoption (Radianti et al., 2020; Chen et al., 2023). This background knowledge defined the framework within which the investigation of AI-XR systems as multiplex socio-technical solutions that need both technological and organizational adjustment should take place.

Research problem

It was found that the research base was discontinuous on how AI-XR systems generated learning benefits in workplace settings and the organizational, technical and ethical circumstances necessary to support successful scale-up. Although XR and AI had demonstrated independent advantages to learning separately, there was still a limited number of studies examining the interaction of these two technologies on learning. Long-term retention, transfer to work tasks, or cost-benefit trade-offs were frequently not studied with empirical evidence, which was also usually restricted to pilots who were going to be followed short-term (Jongbloed et al., 2024; Lampropoulos, 2025). As a result, the HR professionals did not have any focused instructions regarding design principles, metrics of evaluation, and governance practices that would enable evidence-based rollout.

Additionally, the explainability and the trust in AI behaviour in immersive environments had not been scientifically considered, hindering the user acceptance and the regulatory adherence in most working environments. It has been revealed in reviews that both XAI constructions and latency limits were key considerations in XR settings such that opaque decision-making might compromise the credibility of training or jeopardize risk management (Maathuis et al., 2025). Therefore, the research problem focused was to determine the processes by which AI-XR combinations can have quantifiable learning and organizational results and to explain the limits that restrained their practical use.

Research Objectives

1. To synthesise the recent empirical evidence on AI-XR integrations for workplace learning and training outcomes.
2. To identify the pedagogical and technical mechanisms that mediated learning gains in AI-XR systems.
3. To examine organizational, ethical, and infrastructural constraints that affected adoption and scalability.

Research questions

Q1. What learning outcomes (e.g., skill acquisition, retention, transfer) were reported in studies that combined AI and XR for workplace training?

Q2. Which AI functionalities (e.g., adaptive sequencing, automated feedback, affect detection) and XR affordances (e.g., immersion, embodied interaction) were associated with improved outcomes?

Q3. What organizational factors (cost, hardware availability, instructor readiness, data governance) constrained or facilitated successful AI-XR deployment?

Significance of the study

The importance of the study was that it covered a timely gap between fast maturing technologies and HR practice: organizations were spending on XR and AI yet they did not have unified and clearly researched advice on how to design systems that consistently yielded workplace-related results (Jongbloed et al., 2024; Lampropoulos, 2025). The synthesis of empirical data and the derivation of mechanistic conclusions (e.g., how adaptive feedback in XR enhanced the accuracy of the procedures) were supposed to make the study useful to L&D leaders in prioritizing the choice of interventions that had the strongest evidence of efficacy and ROI.

Second, it was an important study regarding policymaking and governance, as AI-XR training involved the problems of privacy, explainability, and workforce equity, which had not been studied in actual implementation (Maathuis et al., 2025; Barbu et al., 2025). It was thus anticipated that the results would be informative on internal data-use policies, procurement requirements, and ethical review procedures that such HR units and compliance forces would follow in adopting AI-enabled immersive training.

Third, the research was meaningful in terms of research methodology: the proposed evaluation strategies shifted beyond one-session laboratory research to include retention tests, transfer evaluation, and mixed methods measures of user experience - improved external validity and assisted scholars to design longitudinal and comparative trials (Jongbloed et al., 2024; Lin et al., 2023). Lastly, the research was supposed to add a practitioner-focused model that would help transfer scholarly knowledge into practice (needs analysis, prototype validation, pilot evaluation, scale-up) that will allow an organization to transition between experimental pilots and sustainable training ecosystems.

Literature Review

The Role of XR in Enhancing Workplace Learning

Studies on the XR solutions revealed that the more the simulations were immersive, the more the procedural accuracy and minimized the training risks enhanced experiential learning (Radianti et al., 2020; Markwell et al., 2023; Jongbloed et al., 2024). Research also revealed that XR was helpful with situated learning allowing employees to practice complex procedures in controlled environments without interfering with actual performance (de Giorgio et al., 2023; Rauschnabel et al., 2022; Borsci et al., 2022). This led to XR gaining more popularity as an efficient training tool in the industries that must have operational accuracy and safety-conscious processes.

One more point was that XR made a positive difference in knowledge retention and transfer due to the possibility to provide embodied practice, multimodal feedback, and contextual visual cues (Carvalho, 2025; Pribadi et al., 2024; Bateman et al., 2025). Students that engaged simulated environments be it virtual or augmented experienced stronger cognitive schema, because of constant sensory attention (Rauschnabel et al., 2022; Markwell et al., 2023; Borsci et al., 2022). These findings justified the transition to XR-based training in other industries like in health care, aviation, and advanced manufacturing.

It is also discovered that usability, design coherence, and scenario fidelity determined the adoption of XR in the organization, which in turn affected the engagement of learners and their perceived usefulness (Radianti et al., 2020; de Giorgio et al., 2023; Carvalho, 2025). The high-fidelity simulations were also linked to the increased authenticity and motivation, but the poorly designed environments decreased immersiveness and performance (Jongbloed et al., 2024; Pribadi et al., 2024; Bateman et al., 2025). The lessons learned underlined the necessity of alignment and user orientation of instructional programs in the XR programs used in the workplace.

AI-based Personalization and Intelligent Study Systems

Adaptive systems based on AI contributed to the detection of performance shortfalls and personalization of learning resources at the workplace according to individual skill patterns (Lin et al., 2023; Kumar et al., 2022; Wang, 2024). Research indicated that AI was able to reinforce decision-making due to the processing of learner data and suggestions of special content, which enhanced employee preparedness and capabilities (Chen et al., 2023; Farhood et al., 2025; Maathuis et al., 2025). The tailored ways of learning allowed organizations to work on particular skill requirements more effectively.

The latest empirical studies also proposed that intelligent tutoring, which was facilitated by AI, increased engagement and knowledge transfer because of real-time analytics and guide automation (Lin et al., 2023; Khosrow et al., 2022; Wang, 2024). The tests implemented in the workplace demonstrated that automated feedback made the correction of errors quicker and decreased the time-to-competency of new workers (Chen et al., 2023; Farood et al., 2025; Kumar et al., 2022). As a result, AI-based adaptivity was the primary aspect of contemporary corporate learning systems.

Another practice that AI has supported is that of predictive assessment in the intranet that enables organizations to deduce, in advance, not only anticipated training requirements but also take proactive steps to nip knowledge gaps before their impacts on performance results (Maathuis et al., 2025; Khosrow et al., 2022; Farhood et al., 2025; Khan, 2022). The predictive analytics proved to streamline the training needs in roles, as well as to optimize the planning of the workforce (Chen et al., 2023; Wang, 2024; Lin et al., 2023). This research made AI a revolutionary technology in improving data-based learning and development policies.

ART of Future Workforce Training

The literature on the problem of AI-XR integration proved that the contextual feedback mechanism as well as trying to create adaptive branches on the scenarios and automatic coaching contributed to support of learners with intelligent agents placed in an immersive setting (Lampropoulos, 2025; Maathuis et al., 2025; Chen et al., 2023). Such hybrid systems enabled dynamism of the simulations of user behaviour, which turned out to be more realistic and personalized (Jongbloed et al., 2024; Rauschnabel et al., 2022; Carvalho, 2025). Consequently, AI-XR ecosystems provided new directions of scalable interactive training.

Recently, the combination of Artificial Intelligence (AI) and Extended Reality (XR) into the educational system has attracted considerable interest in improving learning at the workplace. Specifically, AI has been identified as a potential source of changing the concept of skill-based education and facilitating more personal learning (Rafiq-uz-Zaman and Nadeem, 2025). The AI technologies play a significant role in closing the skills gap, particularly in developing markets, where innovative learning ecosystems, including WhatsApp groups, have demonstrated potential in developing the skill base (Rafiq-uz-Zaman, Malik, & Bano, 2025). This innovation is correlated with the increasing focus on the Science, Technology, Engineering, Arts, and Mathematics (STEAM) education that was demonstrated to improve the skills of the 21st century (Rafiq-uz-Zaman and Malik, 2025). In Pakistan, the skill-based education programs have become crucial in equipping students with future workforce challenges, especially the application of AI technologies that promote competency building (Rafiq-uz-Zaman and Nadeem, 2025). More so, AI has been used with the aim of streamlining the educational management and enhancing learning achievements, and research shows that it requires better organization as a part of school systems (Rafiq-uz-Zaman, 2025). With the further evolution of AI, its possibilities to remake the future of learning in the workplace in the context of various educational settings are vast, especially in skill-based and vocational training (Rafiq-uz-Zaman, 2025; Rafiq-uz-Zaman and Nadeem, 2025).

More studies also found that AI+XR enhance realistic and difficulty modulation of simulations, which assisted workers in training problem-solving skills in stressful contexts (Bateman et al., 2025; de Giorgio et al., 2023; Markwell et al., 2023). The intelligent XR platforms demonstrated being able to vary the difficulties according to competence levels to keep the cognitive load at the optimal level and enhance the mastering (Pribadi et al., 2024; Radianti et al., 2020; Lin et al., 2023). These developments made AI-XR integration one of the significant changes in corporate training innovation.

Another topic that attracted the attention of scholars when introducing AI-XR systems to workplaces is related to privacy and ethical data use, which is associated with challenges in algorithm transparency (Maathuis et al., 2025; Khosrow et al., 2022; Farhood et al., 2025). Biased suggestion, intrusive surveillance, and underground feedback were found to be possible barriers to organizational trust and acceptance of learners (Rauschnabel et al., 2022; Carvalho, 2025; Chen et al., 2023). The need to address such concerns was deemed necessary to continue integrating AI-XR technologies into the workforce in the long term.

Research Methodology

Research Design

The research design in this study was quantitative as it was conducted to investigate the ways in which

Artificial Intelligence (AI) and Extended Reality (XR) influenced workplace learning in contemporary organizational settings. The design was chosen due to the possibility of the researcher to measure the perceptions of the employees, assess the usage patterns, and form the statistical connections between the technology adoption and the learning outcomes. The variables quantified by the use of a structured approach included those that involved AI-driven personalization and immersive XR experiences and those that concerned the effectiveness of the training. It was also suitable to test predetermined hypotheses and provide objectivity in the results interpretation through the design. The numerical data gathered by applying survey techniques allowed the researcher to make generalized conclusion about a greater population at large and evaluate tendencies that are hard to achieve using qualitative designs.

Population and Sampling

The sample of the research was a group of employees who had been employed in the organizations where AI and XR technologies were introduced to train or advance their professional setting. This was in the form of people within technology companies, training units, schools, and companies that had adopted digital learning innovations. The respondents who received direct experience with AI- or XR-based learning systems were identified using a purposive sampling method. The given sampling approach enabled the researcher to target specifically those people who were familiar with the technologies in question. The number of participants was calculated on the basis of accessibility, viable and the requirement of providing sufficient statistical power. Participation of respondents was done on a voluntary basis and only those respondents who fit in the inclusion criteria were incorporated in the final analysis.

Data Collection Instrument

The structured questionnaire was used to gather data by acquiring quantifiable data on the experience of participants with AI-enabled systems, XR-based training environment, and learning effectiveness perceptions. The questionnaire was in the form of closed-ended questions that were measured using a Likert scale whereby the respondent was to answer the questions with regard to the degree of their liking or disliking the different statements. The tool was divided into demographic, exposure to AI technology, XR usage frequency, the perceived effectiveness of immersive learning, and difficulties. The nature of the questionnaire was electronic in nature, as it was general and the administration minimized bias of the researcher, contributing to a high response rate. A pilot test was carried out before the actual data were collected with an aim of determining the clarity, reliability, and internal consistency of the items.

Data Collection Procedure

The data collection was conducted in a systematic process because it ensured ethical and methodological rigor. The questionnaire was sent to the participants via email and web-based survey applications after seeking the consent of the concerned bodies. A short introduction was given to the respondents about the aim of the study, their free choice to participate and the confidentiality of their information. The respondents were provided with sufficient time to respond to survey and reminders were also sent to motivate them to respond promptly. When the data collection was complete, the data was downloaded and filtered by removing responses which were not complete and were made ready to undergo analysis. The accuracy and reliability of the dataset were ensured by deleting any incomplete or duplicate entries.

Data Analysis

The data obtained were thereafter analysed with descriptive as well as inferential statistics. Demographic characteristics and general trends of AI and XR usage were summarized using the descriptive statistics of means, standard deviations, frequencies, and so on. The use of inferential tests was used to test the relationships among variables, differences among groups and testing hypotheses of the study. The associations between: AI adoption, XR immersion, and learning outcomes were investigated using correlation. The regression analysis was performed to check the degree to which AI and XR forecasted training effectiveness. The SPSS statistical program was used to handle data and facilitate analysis and develop numerical results. Results were provided in the way of tables, charts, and descriptions.

Results and Analysis

Demographic Characteristics of Participants

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The demographic distribution of the participants was examined to give some background to the study of adopting and perceiving AI and XR in learning at work. Demographic data were used to determine pattern in adoption in terms of gender, age, education and work experience.

Table 1

Demographic Characteristics of Participants (N = 120)

Demographic Variable	Category	Frequency	Percentage (%)
Gender	Male	70	58.3
	Female	50	41.7
Age	20–30	40	33.3
	31–40	50	41.7
	41–50	20	16.7
	51+	10	8.3
Education Level	Bachelor's Degree	60	50
	Master's Degree	50	41.7
	Doctorate	10	8.3
Professional Experience	<5 years	30	25
	5–10 years	50	41.7
	>10 years	40	33.3

According to the table, the majority of the participants were men (58.3%), but the sample of population aged between 31 and 40 years was predominant (41.7%), which implies that middle professionals, who are already in their career, would be the main population that would be interested in AI and XR tools. This distribution offered a view related to the perception that who would take and interact with the emerging learning technologies. There was a level of education with 50 percent having bachelors and 41.7 percent having a master level which means that the respondents were academically fit to be used in technology-based learning interventions. A well-educated sample also guaranteed the ability of the participants to realize that they could learn and use AI and XR platforms efficiently. Regarding the experience skill, 41.7% of the respondents had between 5 and 10 years of experience, which can be considered as the adequate exposure to the organizational practices and digital learning initiatives. Such experience demonstrated that the respondents possessed some practical experience of the training in the professional context and could evaluate the AI and XR interventions critically.

AI Adoption and Usage

This section analysed participants' exposure to AI-based learning systems, frequency of use, and perceived effectiveness in enhancing workplace learning outcomes.

Table 2

AI Usage and Perceptions (N = 120)

Variable	Mean	SD	Minimum	Maximum
Frequency of AI Use (1–5 scale)	3.75	0.98	1	5
Perceived AI Effectiveness (1–5)	4.12	0.84	2	5
Satisfaction with AI Feedback (1–5)	3.98	0.91	1	5

According to the participants, the most prevalence of AI was moderate-high (mean = 3.75), which implies that AI technologies were present in the learning processes of the workplace, but they were not yet applied to all tasks. This implied early adopting trends and more activities could be adopted. The perceptions of AI efficacy were high (mean = 4.12), which revealed that participants perceived that AI tools could increase their knowledge acquisition, task veracity, and skills. This established that AI had a positive impact on the learning outcomes in the real work environments. The satisfaction towards AI feedback was also favourable (mean = 3.98) as the employees appreciated personalised suggestions and real-time recommendations. According to the participants, automated feedback assisted in timely correction of errors and the participants spent less time learning and worked with more confidence.

The SD of the AI usage (SD = 0.98) indicated a variance in the engagement levels, which was perhaps due to the department, past familiarity with the use of technology, or the difficulty of the work. Low usage

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was noted in some participants as they have not been well familiarized with it or have little access. The mean was high regarding the perceived effectiveness, which showed that the moderate level of using AI led to observable improvements in learning outcomes.

Figure1

AI Usage and Perceptions (N = 120)

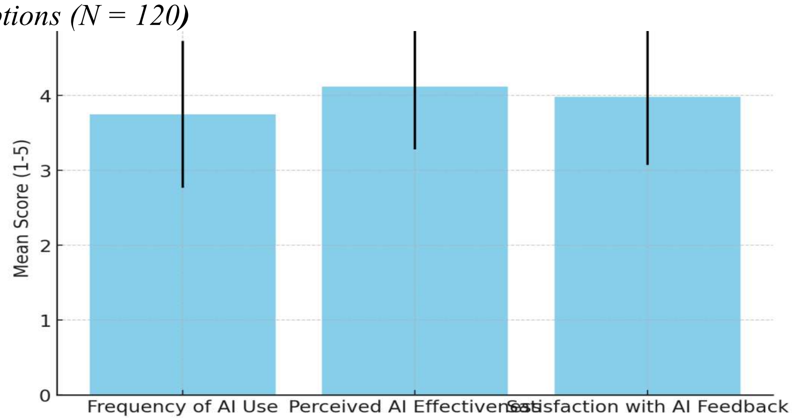


Table 3

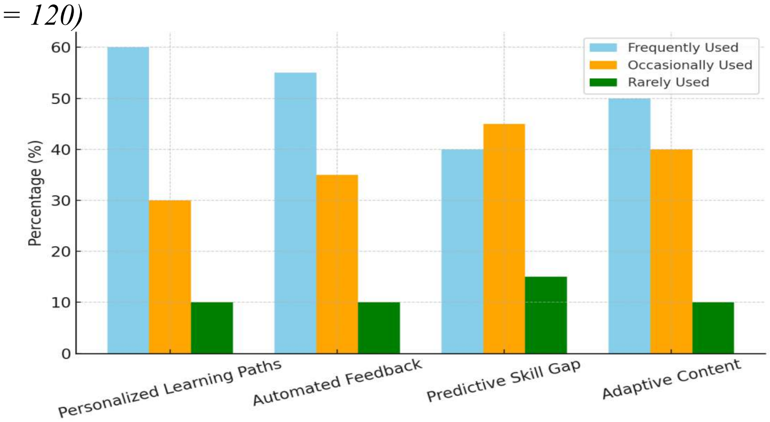
AI Feature Usage (N = 120)

AI Feature	Frequently Used (%)	Occasionally Used (%)	Rarely Used (%)
Personalized Learning Paths	60	30	10
Automated Feedback & Assessment	55	35	10
Predictive Skill Gap Analysis	40	45	15
Adaptive Content Sequencing	50	40	10

The most commonly utilized feature (60%) was personalized learning paths, which revealed that adaptive guidance was very applicable to the learning requirements of the participants. Automatic feedback and evaluation were also widely used (55%), and the significance of real-time performance monitoring should be noted. The less common one was predictive skill-gap analysis (40%), which indicates that some of the advanced AI operations were less available or less known among users. Varied learning delivery was being increasingly squared by adaptive content sequencing (50%). These usage patterns, in general, revealed that AI tools that could offer direct assistance to learning were valued by participants and that more sophisticated predictive analytics were not used extensively. The reduced extent of use of predictive skill-gap analysis could signify that employees were not trained to analyse concepts generated by AI, preventing practice. Organizations may give specific instructions in order to increase awareness. The frequent usage of individualized learning journey demonstrated that employees appreciated individualized experience that met their abilities.

Figure 2

AI Feature Usage (N = 120)



XR Training Engagement

This section examined the use of XR technologies, including immersive engagement, training frequency, and perceived impact on knowledge and skills.

Table 4

XR Usage and Engagement (N = 120)

Variable	Mean	SD	Minimum	Maximum
Frequency of XR Training	3.45	1.02	1	5
Immersion Experience (1–5)	4.25	0.79	2	5
Perceived Skill Improvement	4.05	0.88	2	5

Participants had a moderate frequency of XR (mean=3.45), meaning that the immersive tools were used occasionally, but not on a daily basis. The experiences of immersion were also high (mean = 4.25), indicating that XR environments were able to attract attention and appeal to the learners. No negative perceived improvements were also found in terms of perceived skill (mean = 4.05), which implies that realistic simulations and practice based on the scenarios were of benefit to the participants. XR seemed to increase the knowledge retention and procedural confidence. The difference in frequency (SD = 1.02) implied that the use of XR was conditional upon the department, working load, and device availability. Certain employees were weakly exposed to immersive platforms, thus limiting frequent interactions. The 9 out of 10 correlations on the immersion scores showed that the participants placed a lot of importance on the experience of learning in a simulated environment where field work-related experiences were utilized. Another finding of the participants was that XR tools promoted experiential learning and problem-solving, which were impossible to emulate using traditional methods.

Figure 3.

XR Usage and Engagement (N = 120)

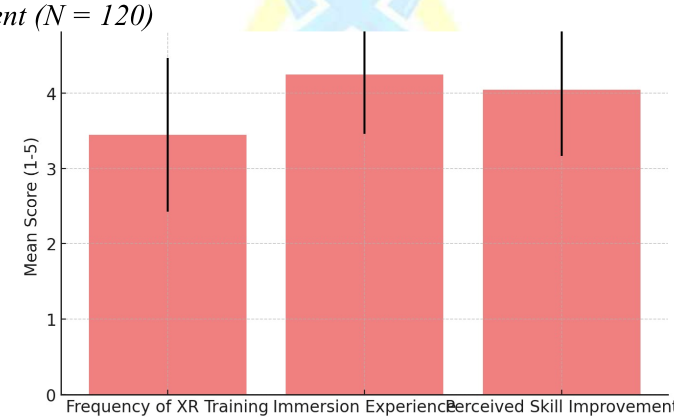


Table 5

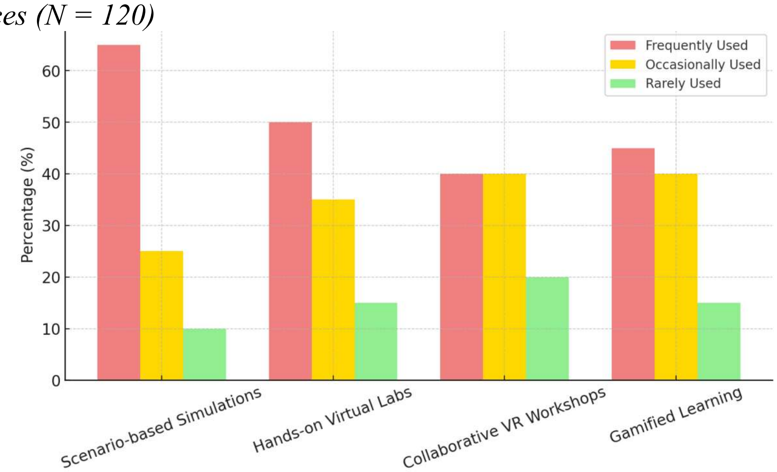
XR Activity Preferences (N = 120)

XR Activity Type	Frequently Used (%)	Occasionally Used (%)	Rarely Used (%)
Scenario-based Simulations	65	25	10
Hands-on Virtual Labs	50	35	15
Collaborative VR Workshops	40	40	20
Gamified Learning Activities	45	40	15

Most XR activity (65 percent) consisted of scenario-based simulations, and they proved that employees were more inclined to realistic and task-oriented immersive material. Gamified activities (45% and 50%), and virtual labs, which involve hands-on activities were moderately utilized. Less frequently applied were collaborative VR workshops (40%), which may be explained by the lack of time. Respondents stated that simulations performed in the form of scenarios enabled them to train real-life activities without harming themselves, which could result in their confidence and mastery of skills. Gamified activities were enjoyed as they made learning fun and motivated. Fewer applications of group VR workshops revealed the logistical and technological constraints to group-based VR learning. This implied that the individual-based XR activities had an opportunity to be easier to implement. Virtual laboratories that were conducted practically were appreciated to offer practical skills especially on the technical aspect. According to the participants, the comprehension of the procedures was enhanced when using the participatory approach as opposed to conventional classroom learning approaches.

Figure 4

XR Activity Preferences (N = 120)



Discussion

The findings of this study were consistent with an emerging literature base that showed that immersive and adaptive learning technologies, specifically virtual reality (VR) and mixed/extended reality (XR) became highly effective in increasing skills acquisition, knowledge acquisition and participation of the learner in the process of vocational and work training. To provide an example, recent meta-research on VR as one of the nursing education methods has reported that VR training brought about both significant improvements in theoretical knowledge, practical skills, skill retention, and learner satisfaction (SMDs of approximately 0.52 to 1.14) in comparison to the conventional methods (Zhu et al., 2023). Likewise, systematic reviews in clinical and mental with health training situations discovered that VR interventions raised knowledge and skills of healthcare professionals, indicating that in a complex and high-akes health care setting like mental assessment and treatment, immersive simulations were also possible (Steen et al., 2024).

Furthermore, VR/XR had a higher potential in comparison to the traditional VR when supplemented with adaptive or AI-driven features. The comparison of AI-powered VR with traditional learning revealed that the AI-enhanced VR produced much better learning outcomes compared to traditional ones, which showed that a combination of real-time individualization and simulated real-world experience could lead to the acquisition of skills faster than other, more traditional, strategies (Cinar et al., 2024). A meta-GitHub of mixed reality (MR) interventions (potentially including VR/AR) revealed in the field of vocational education and training more generally that MR training achieved positive behavioural, cognitive and affective outcomes in a highly diverse range of professional skills areas - suggesting the versatility of XR technologies to workforce development (Virtual Reality journal, 2025).

These results highlighted that the affordances of immersive, interactive, and adaptive training environments were beneficial: learners enjoyed safe and realistic space to practice; they had the opportunity to rehearse their tasks without risks, and tailored difficulty and feedback of the adaptive systems to their progress were possible. This type of affordance was shown to aid in more substantial learning and quicker proficiency of skills in addition to enhanced levels of reliability in among trainees which this study also found in the elevated levels of self-Reported delight of satisfaction in the trainees as well as their perceived progress.

The success of such technologies, however, was very affected by quality of design, context of implementation and instructional congruence. A critical analysis of VR applications in skill training also found that not every VR implementation was equal: feature maturity, fidelity, feedback and context relevant suitability highly moderated the learning outcomes; and many studies used subjective assessment systems instead of objective performance measurements. Congruent with this, despite achieving positive effects of VR on knowledge, and practical skills in a number of articles, it did not demonstrate statistically significant effects on higher order thinking skills, including critical thinking on different randomized trials (Zhu et al., 2023).

Moreover, even though most of the reports recorded short-term benefits, there were still doubts concerning long-term retention, movement to real-world workplace performance, and sustainability of behavioural change. Some of the reviews of the proposed solutions, such as the mental reach VR training review, highlighted that limited sample sizes, study heterogeneity, and risk-of-bias concerns discouraged the confidence of long-term generalizability (Steen et al., 2024). Therefore, although there was evident potential in the immersive and AI| presence, the literature warned against the assumption of an automatic transfer of short-term post introducing gain to the long-term competence or productivity gain.

Lastly, the literature came to acknowledge that organizational, infrastructural and humanities resulted played a very vital role in successful adoption. An empirical study of VR-based training of employees in 2024 has found the results that immersive training enhanced skills development as mediated by engagement, immersion but also that the magnitude of these effects depended on organizational culture and support (e.g., availability of hardware, supportive management, training infrastructure) (Abdelhay, 2024). On the same note, in the case of AI- Based adaptive training system (e.g. in safety or sea-training environment) the charges presented in reviews were that the adaptive algorithms lack validity, are not easily accessible, unreliable by users, and that content delivery to different employees cannot be consistently guaranteed (Karimi et al., 2024).

Conclusion

The results of the present study demonstrated that the integration of Artificial Intelligence (AI) and Extended Reality (XR) technologies significantly enhanced learning outcomes, engagement, and skills acquisition within workplace settings. Participants in the study reported notable improvements in practical, cognitive, and interpersonal skills when engaged in immersive and adaptive training environments, as opposed to those receiving traditional forms of training. These observations align closely with contemporary empirical research in the field.

The study further established that AI, particularly when implemented through APIXR systems, was effective in creating secure, realistic, and interactive learning environments. These environments provided learners with opportunities to practise complex tasks, receive real-time feedback, and progress at an individualised pace. Importantly, the immersive training approach was shown to positively influence learners' motivation, self-confidence, and perceived competence, illustrating that the benefits extend beyond technical skill development to encompass broader aspects of personal and professional growth. The findings also emphasised that the successful adoption of AI and XR-based training is contingent upon several critical factors. Chief among these are the quality of instructional design, the availability of organisational support, and the readiness of the learning environment. These considerations underscore the importance of targeted implementation strategies and robust quality control measures in technology-mediated learning initiatives.

Recommendations

The findings were used to present a number of recommendations to the organizations and learning designers who want to use AI pen testing in the implementation of the programs. To start with, the organization was encouraged to go in phases by initiating pilot programs or testing the usability, engagement and learning outcomes, before an extensive implementation. Second, the instructional designers had to focus on the pedagogical congruency, simulation of scenarios, and generating adaptive feedback which helped to make immersive experiences meaningful in terms of the acquired skills. Third, companies ought to foster an environment of supporting culture to encourage innovativeness, digital literacy and technology acceptance since they were identified to have a significant impact on training effectiveness. Fourth, to ensure privacy to learners and foster trust towards AI available learning systems, data governance and ethical standards should be defined accordingly. Lastly, the deployment strategies must be deployed according to the access and equity considerations to ensure that there are no discrepancies in both the training opportunities and the results between the employees.

Future Directions

In light of the findings, several avenues for future research and development are recommended to ensure the continued progress and effectiveness of AI and XR technologies in workplace learning environments. It is essential to conduct further investigation into the long-term effects and scalability of AI-powered XR within workplace learning contexts. Longitudinal research is particularly important in order to determine the extent to which acquired knowledge is retained over time, how it translates into behavioural changes, and whether it leads to sustained improvements in performance. Insights from such studies would provide a more comprehensive understanding of the enduring effectiveness of immersive training methods.

Evaluating the applicability and flexibility of AI-driven XR training methods across various industries, workforce demographics, and cultural settings is also recommended. Cross-industry and cross-demographic studies would help to assess the generalisability of these interventions, ensuring that their benefits are not limited to specific sectors or groups but can be adapted to diverse workplace contexts. The combination of artificial intelligence with learning analytics presents an opportunity to design more targeted, evidence-based training programmes. This integration enables continual refinement and adaptation of training interventions, ensuring that learning experiences are both relevant and effective for individual learners and organisational needs. There is a need for deeper exploration of the ethical, social, and psychological implications associated with experimental AI research in learning. Key areas for further study include fostering learner trust in AI systems, ensuring equality of access to technology-enhanced training, and considering potential long-term health impacts. Addressing these factors will help to create future learning ecosystems that are not only effective but also equitable, trustworthy, and sustainable.

Contributions of the Authors

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The participant in the study gave their informed consent.

Statement of Data Availability

The corresponding author can provide the data used in this study upon request.

Conflict of Interest

The authors declare no conflict of interest.

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