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Review

Intelligent Immersion: AI and VR Tools for Next-Generation Higher Education

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Abstract

Learning is fundamentally human, even as Artificial Intelligence (AI) challenges human exclusivity. AI, along with Virtual Reality (VR), emerges as a powerful tool that is set to transform higher education, the institutional embodiment of this pursuit at its highest level. These technologies offer the potential not to replace the human factor, but to enhance our ability to create more adaptive, immersive, and truly human-centric learning experiences, aligning powerfully with the emerging vision of Education 5.0, which emphasizes ethical, collaborative learning ecosystems. This research maps how AI and VR tools act as a disruptive force, examining additionally their capabilities and limitations. Moreover, it explores how AI and VR interact to overcome traditional pedagogy's constraints, fostering environments where technology serves human learning goals. Employing a comprehensive two-month audit of over 60 AI, VR, and AI-VR hybrid tools, the study assesses their functionalities and properties such as technical complexity, cost structures, integration capabilities, and compliance with ethical standards. Findings reveal that AI and VR systems provide significant opportunities for the future of education by providing personalized and captivating environments that encourage experiential learning and improve student motivation across disciplines. Nonetheless, numerous challenges limit widespread adoption, such as advanced infrastructure requirements and strategic planning. By articulating a structured evaluative framework and highlighting emerging trends, this paper provides practical guidance for educational stakeholders seeking to select and implement AI and VR tools in higher education.

Keywords: AI-VR educational integration; intelligent immersive learning; educational technology review; adaptive and personalized learning systems; virtual reality laboratories in higher education; education 5.0; AI-VR educational tools; innovation in higher education

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1. Introduction

Throughout history, the tools produced by technological advances have dictated how people learn and relate to the world. In the educational context, the invention of the printing press in the 15th century created a significant shift, breaking the monopoly of handwritten manuscripts and making knowledge accessible to everyone. Centuries later, the rise of the internet, erased geographical barriers and connected classrooms and human brains to a global network of information, ideas, and cultures. Central to this transformation were platforms that provide online courses, digital libraries and Learning Management System (LMS) turned pupils into active participants who collaborate, create, and share knowledge on an unprecedented scale. Today, as AI and VR emerge as defining innovations of the 21st century, they signal a new paradigm in education Education 5.0: a human-centric paradigm that links intelligent technologies, ethical AI, and collaborative human-machine ecosystems to address societal challenges, foster creativity, and empower learners as co-creators of sustainable, equitable futures.

These pillars of Education 5.0 are already taking shape through AI and VR innovative tools. AI's capacity to analyze vast datasets and tailor instruction to individual needs, combined with VR's

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ability to transport learners into simulated environments, from molecular biology labs to ancient archaeological sites, promises to transcend the limitations of traditional classrooms. AI-powered tools like Gradescope and Knewton Alta are already demonstrating the impact of AI in education by offering personalized feedback, automating assessment processes, and reducing administrative burdens (Stanyon et al., 2022). Meanwhile, platforms like Axon Park and AnatomyX are pushing the boundaries of immersive learning. Axon Park offers realistic, 3D virtual campuses where students can collaborate and practice complex skills. In contrast, AnatomyX focuses on medical education by providing hands-on interactive 3D anatomy lessons.

Despite their potential, effectively integrating AI and VR presents significant challenges. Current implementations often lack cohesive strategies that align technical capabilities with pedagogical goals, limiting their impact on actual learning outcomes. Moreover, ethical concerns such as data privacy and algorithmic bias, alongside broader challenges like digital equity and teacher training, pose significant challenges for widespread adoption. Without careful planning, these tools can add complexity without improving learning outcomes while also potentially exacerbating discrimination among students.

This paper explores the tools that are making this transformation possible, drawing on a comprehensive audit of AI and VR technologies (Appendix A). It reviews the current landscape of AI and VR tools in higher education, highlights the most impactful, and discusses the challenges of integrating them effectively. By focusing on technical requirements, functionalities, technical complexity, integration capabilities, and pedagogical alignments, this work aims to provide practical guidance for educators, researchers, and policymakers looking to shape the future of learning.

2. Literature Review

AI is changing education by making learning more personal and flexible by using data to create tailored experiences for each student. Recent studies identify three dominant approaches to AI integration: AI-directed, AI-supported, and AI-empowered learning (Ouyang & Jiao, 2021). These reflect a shift from teaching based on algorithms to true, self-directed learning networked environments. For instance, AI-directed platforms rely on structured content and rule-based reinforcement principles. These ideas come from behaviorist learning theories (Skinner, 1958). The goal is to help users learn through automated feedback and organized lessons.

In contrast, the emergence of tools based on the former approaches —AI-supported and AI-empowered tools —aligns closely with constructivist and connectivist theories. Consequently, the new tools provide greater emphasis on student agency and knowledge construction. Adaptive learning systems now use machine learning techniques and functionality such as natural language processing, predictive analytics, and data visualisation. The results are significant. They create customized learning paths, improve assessment methods, and help predict which students may be at risk of leaving.

The application of advanced tools for providing individual student feedback at scale, particularly in mathematical disciplines, can significantly improve student assessment and learning outcomes. Stanyon et al. (2022), for example, demonstrate how the integration of computer algebra and machine learning enhances feedback mechanisms in STEM education. The authors explain that the application of tools that provide individual student feedback at scale, in mathematical disciplines at least, can significantly improve both assessment and learning outcomes. Moreover, the integration of predictive analytics tools has shown a measurable impact on institutional student retention and targeted intervention strategies.

Despite these advances, significant challenges persist. Main concerns among them, are the limitations in contextual feedback, the risk of algorithmic bias, and the ongoing concerns about data privacy and ethical use (Owan et al., 2023; Balta, 2023). As the European Parliamentary Research Service highlights, robust data governance and explainable AI are now prerequisites for responsible integration. The literature further reveals ongoing debates about over-reliance on automated feedback and the risk of diminishing critical thinking and creativity (Sartor & Lagioia, 2020).

As AI reveals both its benefits and challenges in higher education, VR is becoming an important tool for hands-on learning, promising cost efficent practical experience while providing safe practice. Systematic reviews, including those by Radianti et al. (2020), show that virtual reality environments consistently lead to improvements in knowledge acquisition, motivation, and retention across various fields, such as medicine, engineering, and the arts. Platforms like AnatomyX and Fundamental Surgery demonstrate the effectiveness of realistic, hands-on virtual simulations, especially in the health sciences. VR tools reinforce both cognitive and procedural skill development in these scenarios.

Recent empirical studies confirm these benefits. Lindner et al. (2024) found that immersive VR-based medical training led to significantly higher knowledge retention at 30 days post-intervention compared to video-based seminars. Benefits are not limited to health sciences alone. In design and creative disciplines, VR sketching tools like Gravity Sketch and Tilt Brush have been shown to enhance creative output and spatial reasoning skills, with students demonstrating deeper engagement and improved project outcomes (Lin et al., 2022; Stephen & Kunnumpurath, 2024).

However, VR integration is not without hurdles. Issues such as cost, hardware requirements, VR-induced discomfort, and uneven access persist. The literature also notes that institutional support and technical infrastructure are prerequisites for scalable adoption.

Despite these individual challenges in the widespread adoption of both AI and VR, the latest developments highlight an increasing convergence of these two technologies. Hybrid platforms, such as Axon Park and Metaversity, combine AI and functionalities to create "digital twin" campuses and personalised educational journeys. These initiatives align with the principles of Education 5.0, promoting a human-centric, collaborative but at the same time ethical integration of intelligent technology. However, developing and using these hybrid solutions, institutions must face the combined challenges of AI and VR, especially the requirement of advanced technical skills and significant investment.

Several cross-cutting themes further emerge from recent literature, such as scalability and integration. AI and VR educational tools are mainly offered through paid subscription platforms. This makes it hard to scale and integrate them into existing learning systems, like LMS. (DigitalDefynd, 2025). It has been noted that there is increasing attention toward modular integration via Application Programming Interfaces (APIs), which can facilitate the incorporation of diverse educational technologies into curricula (Uptale, n.d.; Paradiso Solutions, 2025; Tomorrow Desk, n.d.). This modular approach helps schools and organizations use AI and VR tools designed for their specific educational needs. It ensures these tools work well with other technologies, which could improve the overall learning experience (Uptale, n.d.; Paradiso Solutions, 2025).

Another key theme is disciplinary specialization, recognizing the varied effectiveness of AI and VR tools across disciplines. Research indicates that while general applications exist, domain-specific tools yield significant advancements in learning outcomes, particularly in fields such as medicine and STEM education (Stavroulia & Lanitis, 2019; Kyaw et al., 2019).

Equity and access are important topics in the literature argues that these challenges disproportionately impact under-resourced institutions and students from various socio-economic backgrounds. As this study illustrates, most tools are not only behind paywalls but also require enterprise-level subscriptions. OECD (2024) explains that there is a pressing need for equitable cost models and investment in open-source solutions to ensure inclusive benefits from advanced learning tools (OECD, 2024).

Furthermore, ethical and data privacy concerns are important topics in the literature. Smyrnaiou et al. (2023) highlight the importance of respecting human autonomy, preventing harm, ensuring fairness, and providing explicability. Finally, a common theme in literature is the impact of professional development and AI on the professorial role and career. Professional development is essential for successful adoption, as faculty may not only lack knowledge but also fear for their job security. Professional development initiatives must focus on equipping educators with the necessary competencies to effectively integrate these technologies into their teaching practices (Pan, 2024b).

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3. Methodology

This research methodology systematically mapped the diverse landscape of AI and VR tools in higher education. Recognizing the rapid evolution of educational technologies, the author conducted an extensive two-month data collection process. This process involved gathering information from a wide range of sources, including academic articles, industry reports, technical manuals, platform websites, and, where possible, hands-on testing. The objective was to compile a comprehensive dataset encompassing both established and emerging AI, VR tools, and hybrid AI-VR tools. Moreover, this dataset aims to reflect how different educational settings use various applications. To ensure transparency and reproducibility, the complete dataset of analyzed tools is provided in Appendix A. This dataset details critical attributes, including functionality, technical complexity, cost model, target discipline, and ethical and privacy compliance, providing a detailed foundation for the analysis presented in this paper.

Tool selection employed rigorous criteria aligned with the research objectives. The study emphasized platforms that applied practical methods in education, especially those with substantial user bases or recognition in academic literature. The examined tools encompass AI-driven platforms like Gradescope, known for automated assessment and personalized feedback, alongside VR-based environments such as AnatomyX, which provide immersive medical simulations. Hybrid platforms, providing AI and VR functionalities, were also included, as they represent a growing trend in educational technology. The final selection aimed for breadth across application types and disciplines.

The author developed a structured framework to evaluate each tool based on clearly defined criteria. The analysis assessed technical complexity, ranging from basic cloud-based systems needing minimal setup to advanced platforms requiring specialized hardware and expertise. Cost models were examined, distinguishing between three types: subscription services, open-source platforms, and one-time licenses. Integration capabilities formed another key focus area. This specifically evaluated seamless compatibility with existing learning LMS and institutional infrastructures.

This evaluation process encountered challenges, primarily stemming from inconsistent documentation quality across the tools. Challenges arose from inconsistent documentation quality across tools. Some offered detailed specifications while others provided only basic descriptions, complicating comparative analysis. Furthermore, the rapid pace of innovation meant that some tools were updated during the assessment. When discrepancies in data occurred, the author conducted additional analysis.

As noted earlier, the resulting comprehensive dataset underpinning this analysis is presented in Appendix A. It includes ethical/privacy compliance, technical complexity, cost models, target disciplines for each platform, and more, providing the critical foundation for the statistical analysis in the Trends and Key Findings section. This structured dataset enables robust identification of patterns, gaps, and dominant trends within the AI/VR educational technology landscape.

4. Tools and Technologies

The integration of AI and VR into higher education relies heavily on a diverse range of specialized tools, each designed to address different educational needs and challenges. Understanding the capabilities and limitations of these tools is critical for institutions, teachers, and students aiming to harness their full potential. These tools can be broadly categorized into three primary types based on their underlying technology: AI, VR, and hybrid systems that blend both approaches.

Simply categorizing tools by their technological foundation is insufficient; practical, pedagogical, and institutional contexts must also be considered. Therefore, this research incorporated additional criteria to reflect the real-world challenges encountered by educational stakeholders. Therefore, the research incorporated the following additional factors.

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First, the purpose and functionality of a tool are vital. Equally important is the technical complexity of the tool, as certain platforms require considerable IT support and specialized hardware, such as a VR Headset. Conversely, others are engineered for seamless, plug-and-play integration. Connected to the previous factor is the Integration capabilities. Tools that seamlessly integrate with existing LMSs simplify data sharing through APIs or plugin functionality for other software. These features help create a smoother experience for teachers and institutions alike. Long-term integration capabilities also help to reduce costs, a concern that transitions naturally into another key factor: financial and ethical accessibility. Specifically, cost models can vary widely, from subscription-based platforms to one-time purchases or even open-source solutions, each with different implications for institutional budgets. Tool affordance is important as it raises ethical issues because low-funded small institutions cannot provide the necessary resources that ensure digital equity. Thus, ethical and privacy considerations are an important factor in this study. Educational tools must comply with data protection regulations, such as GDPR and FERPA, to ensure they respect students' privacy, dignity, and autonomy.

Scalability and flexibility are also paramount. Some tools are designed for small, specialized programs, while others can scale to support large classes or even entire institutions. Scalability and flexibility are also paramount. Some tools are designed for small, specialized programs, while others can scale to support large classes or even entire institutions. Yet, scalability alone is insufficient; tools must align with pedagogical priorities, ensuring technology supports established learning theories. These theories align with principles that harmonize with the personalized, collaborative, and human-centric goals of Education 5.0. The target disciplines and audiences for these tools also play a critical role, as some platforms are designed for specialized fields like medicine, engineering, or language learning, while others are more broadly applicable.

Finally, the hardware requirements vary depending on the tool's functionality, whether it involves AI, VR, or both. AI tools often run smoothly on everyday devices like laptops or smartphones, lowering the barrier to entry. Advanced AI models behind them actually require immense computing power to train. However, AI tool providers handle all that heavy lifting behind the scenes, so institutions and users don't have to worry about it. VR tools, however, face a steeper climb: headsets, motion sensors, and other specialized gear can inflate costs and create logistical headaches, especially for institutions with limited budgets or IT support. By evaluating tools across these factors, institutions and professors can make better-informed decisions about which tools and technologies are best suited to their specific educational needs and long-term goals.

4.1. AI Tools

AI tools are foundational to personalized, data-driven learning. They also streamline administrative tasks, grading, and student engagement. Moreover, they increasingly empowered teachers to leverage the vast amounts of data to improve their instructional practices. For example, platforms like ALEKS and Knewton Alta use adaptive algorithms. Research indicates that Knewton's adaptive learning system leverages user data to create unique pathways for students, which can result in improved engagement and academic performance (Baker, 2016; Kerssens, 2023). Additionally, ALEKS excels in STEM. More than 85% of students reported a positive learning experience and an increased likelihood to stay in a math-based program with the use of adaptive learning software like ALEKS (Bernhardt-Walther and McKeown, 2023). Further, at Texas A&M University, students using ALEKS in chemistry achieved improved outcomes, with those completing a Chemistry Reinforcement Module experiencing an average 1.31 GPA point difference compared to non-completers. Notably, students in the bottom 20% also showed a noticeable improvement in GPA and passing rates (McGraw Hill Education, n.d.). Century Tech, a leader in adaptive learning, was created to provide tailored learning paths specifically for STEM courses. The platform continuously learns how each student learns and dynamically adapts to their strengths and weaknesses, delivering tailored support or challenge as needed (CENTURY Tech, 2024). At the same time, CENTURY automates routine teaching tasks, such as grading assessments and tracking progress, which

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significantly reduces teacher workload and frees up instructors' time for direct teaching; for instance, in a recent Liverpool City Region pilot, teachers saved an average of over nine and a half hours each, time that could instead be devoted to student support (CENTURY Tech, 2025). Brightspace is more than just a traditional LMS. It integrates generative AI tools like Lumi Practice and Lumi Questions, allowing educators to quickly create practice exercises and quiz questions from existing course content. These tools reduce the time required for assessment creation while maintaining academic integrity. Additionally, its Creator+ toolset converts content into interactive experiences, thus promoting deeper student engagement. The platform dashboard tracks AI usage, helping teachers make decisions based on data (D2L, 2025).

But AI is not limited to platforms, it also thrives in all types of educational applications, especially those that include real-time interactions. Conversational AI tools such as Cognii provide open-ended, adaptive tutoring through NLP, delivering personalized feedback and promoting critical thinking. Cognii's virtual learning assistant encourages students to think critically and formulate open-ended responses, providing personalized real-time feedback and one-on-one tutoring to foster active knowledge construction in line with constructivist learning principles (Tulasi & Rao, 2023). Another example is Duolingo, which leverages AI-driven speech recognition to offer instantaneous pronunciation feedback. Duolingo has been adopted as a supplementary tool in tertiary language programmes, where its bite-sized, game-like exercises and adaptive review cycles yielded significant gains in students' vocabulary mastery and high levels of learner engagement (Febrianti et al., 2024).Similarly streamlining workflows, Gradescope integrates with LMS platforms like Canvas to flag potential plagiarism in programming assignments by checking for similarity above a configurable threshold—enabling instructors to review suspect submissions instantly and maintain consistent evaluations across large cohorts (Mukasa, 2021).

Having seen how AI streamlines both learning and assessment, it also underpins institutional integrity and student support. Beyond supporting learning, AI also plays a guardian role in academic integrity. Platforms like Turnitin use AI algorithms to detect plagiarism and provide textual similarity reports. According to Turnitin (2024), since its launch in April 2023, the AI writing-detection feature has reviewed over 200 million student papers, underscoring its widespread adoption in higher education. Hattie et al. (2021) note that Turnitin already includes automated grammar and mechanics feedback, flexible teacher-generated comments, and multiple inline and summary feedback streams, features shown to contribute significantly to improvements in student essays over successive revision cycles. This dual focus—on both ethics and support—extends to student retention, where predictive analytics platforms like Civitas Learning identify at-risk students by analyzing engagement patterns and academic performance. For example, Civitas Learning analyze student demographic, academic, and engagement data to generate individualized risk scores; for example, after deploying Civitas Learning's analytics, Monroe Community College achieved a 6% increase in student retention (MMD, 2021). Sana Labs is a platform not only for education but also for business. According to Sana Labs' white paper on evidence-based learning designs, moderated by Ken Hubbell, its AI platform leverages real-time learning analytics to surface patterns of learner struggle, dynamically adapt content sequencing, and recommend targeted instructional adjustments to address emerging knowledge gaps (Hubbell, 2021).

Efficiency is another key area where AI shines. Automated grading systems like Graide reduce grading time while improving feedback quality through rubric-based evaluations. Automated scoring systems deliver rapid, consistent feedback and greatly reduce instructor workload, but they also introduce ethical challenges around fairness, such as algorithmic bias and limited cultural sensitivity, that can affect diverse student populations (Bulut et al., 2024).

AI tools influence all domains, including communication. Language learning and writing, which are fundamental skills in education, have also been transformed. Duolingo uses speech recognition technology to give users real-time feedback on their pronunciation. This renders learning a new language interactive and easy to access. In writing, Grammarly and Turnitin's AI-powered assistant help students improve grammar and style. Yet, as with all AI tools, educators must guide students to critically evaluate automated suggestions rather than passively accepting corrections.

Finally, institutions are embedding AI not only through native LMS features but also by integrating best-of-breed AI services via APIs and extensions. Examples include linking large language models to course content using mechanisms like Dynamic Course Content Integration (DCCI) in the Ask ME Assistant, deploying AI-powered chatbots for 24/7 student support, auto-generating quizzes and feedback with generative AI modules, incorporating proctoring services for exam integrity, and feeding rich analytics from external learning-record stores into platforms like Blackboard and Moodle (Mzwri & Turcsányi-Szabo, 2025). This hybrid approach lets universities blend specialized AI capabilities directly into their existing frameworks, enhancing functionality without replacing core systems.

4.2. VR Tools

Virtual Reality tools create engaging learning experiences that help students learn better than traditional methods. A systematic review found that such VR applications yield moderate to significant gains in knowledge acquisition and student motivation across disciplines (Radianti et al., 2020). The authors list seventeen benefits of using immersive VR in higher education. These benefits include better learning outcomes, increased motivation, and better engagement with course material. VR tools are particularly effective for disciplines that require hands-on practice, such as medicine, engineering, and architecture. AnatomyX, for instance, provides detailed 3D anatomical models, allowing medical students to explore the human body in a risk-free, interactive environment. Similarly, Fundamental Surgery provides haptic-enabled VR simulations of key surgical procedures. Its haptic-enabled modules have demonstrated strong face validity and improved procedural competence in randomized pilot trials (Fundamental VR, 2019). This approach not only enhances anatomical understanding but also improves retention by providing realistic, context-rich experiences. Another study led by UCLA's David Geffen School of Medicine in the Journal of Surgical Education found that surgical performance using Osso VR improved by 230% compared to traditional methods (Osso VR, 2022). VR tools are also useful and applicable in various general studies. Suhag (2024) found that VR-enhanced courses produced a statistically significant increase in student engagement compared to traditional methods ($p < 0.05$).

Moreover, collaborative VR platforms like ClassVR extend immersive learning into shared virtual spaces, enabling students to work together in real-time on complex, interactive tasks. Van der Meer et al. (2023) identify five distinct affordances of VR for collaborative learning—enhanced engagement and motivation, support for both co-located and remote collaboration, provision of interdisciplinary virtual spaces, development of social skills, and alignment with collaborative learning paradigms. Platforms like ClassVR and BodyMap exemplify these affordances by letting students jointly manipulate 3D models and communicate in real time within richly contextualized simulations, deepening both subject-matter understanding and essential teamwork competencies. Bringing learners together in practical simulations helps them understand the subject better. These tools also build important collaboration and soft skills that are essential in higher education.

4.3. AI-VR Hybrid Tools

Integrating AI and VR has emerged as a promising educational frontier, one where cognitive training and assessment align with instructional strategies that prioritize experiential learning. There are already some platforms that integrate both AI and VR, combining the personalized learning capabilities of AI with the immersive potential of VR. Axon Park uses a multimodal learning model that combines AI analytics with VR simulations. This approach creates a complete educational experience. Likewise, ENGAGE XR features Athena AI, a virtual assistant that understands natural language within the VR environment, generates contextual images on demand, and aggregates participation data for instructors via its analytics dashboard (ENGAGE XR, n.d.). Nowadays, platforms are emerging that offer a complete solution, aiming to provide a digital twin of a university

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with integrated AI and VR capabilities. For example, VictoryXR's Metaversity builds digital-twin campuses in VR, complete with AI-powered conversational tour guides and on-the-fly tutoring agents that respond to student queries, blending campus orientation with adaptive learning support (VictoryXR, n.d.). This fusion of adaptivity and immersion aligns with situated-cognition theory by situating learners in realistic, context-rich simulations that both challenge and support them at the optimal level.

5. Specialized Tools by Discipline

A thorough examination of the educational technology landscape shows that many AI and VR tools are tailored to meet the specific needs of various academic disciplines rather than being general-purpose. There are tools that are interdisciplinary in nature. These tools often merge various approaches, including virtual reality and other technologies, with the ultimate goal of creating digital twins of universities. While discipline-specific tools can sometimes outperform generic platforms, they do so by addressing the unique pedagogical nuances and workflows specific to each academic field.

In the medical sciences, tools such as AnatomyX and Osso VR provide simulations that allow students to practice surgical techniques and explore anatomical structures without the risks associated with using live patients. These platforms achieve this realism through advanced technical capabilities, often incorporating advanced haptic feedback and 3D visualization, creating highly realistic practice environments. For instance, Medivis (2019) explains that AnatomyX offers medical students, instructors, and administrators a platform that leverages CT and MRI data to generate over 5,000 photorealistic anatomical structures, voice and gesture navigation, and cloud-based analytics for tracking student progress.

Additionally, these tools promise better learning outcomes compared to traditional methods. For example, a randomized, controlled trial by Lindner et al. (2024) found that medical students who completed a fully immersive VR-based emergency-medicine scenario (with automated feedback) retained significantly more applied knowledge at 30 days (mean gain +17.8 %) compared to peers who learned via a matched video seminar (+11.9 %), indicating that VR can yield measurable long-term benefits even in short (35-minute) training sessions. Several individual studies report substantial procedural-skill gains (effect sizes between 13.9% and 68.4%) for VR-trained medical students compared to conventional methods. However, when Liu et al. (2023) pooled these results, the aggregate effect did not achieve statistical significance, and the reviewers accepted the null hypothesis.

In STEM disciplines, platforms like ALEKS and Knewton Alta focus on adaptive learning. AI in STEM higher education enables the creation of customized, adaptive learning pathways by processing extensive data on student achievements, preferences, and learning styles to recommend content uniquely suited to each learner (Nagaraj et al., 2023). The authors explain that these systems enhance learning by tailoring instruction speed, complexity, and focus to individual needs, improving outcomes in challenging STEM concepts.

In general, adaptive learning systems have shown satisfactory results not only in STEM fields but across various subjects as well. Across multiple implementations, adaptive learning systems have demonstrated a reduction in time to mastery by an average of 30% compared to static digital content (Digital Promise, 2020). Completion rates for adaptive courses average 15–22% higher than traditional digital courses (Online Learning Consortium, 2021). A comprehensive evaluation of 26 adaptive learning implementations reported a moderate overall effect size (Hedges' g = 0.36), indicating meaningful but varied impact across contexts (SRI International, 2022). Additionally, Yazdi et al. (2024) explain that by adding VR to online STEM courses, schools can create realistic lab simulations and demonstrate industrial processes. The authors support that this approach boosts student engagement and understanding. This is the primary reason that VR tools are popular in STEM studies.

Just as VR simulations optimize STEM education, AI-powered language platforms utilize NPL algorithms to customize lessons in real time. Language learning platforms like Duolingo help students learn by examining their pronunciation and progress. They adjust the exercises based on pupils strengths and weaknesses, which helps them learn a language faster. For instance, independent learners who used Duolingo's app for roughly 3 months (~27 hours) showed significant improvements across all language skills – including reading, writing, listening, speaking, grammar, and pronunciation – demonstrating that such apps can enhance a broad range of abilities (Smith et al., 2024). Jiang et al. (2022) found that learners who completed Duolingo's beginner-level Spanish or French courses achieved reading and listening proficiency levels comparable to those of university students after about four semesters of language instruction). Consequently, higher education institutions are increasingly adopting AI tools to complement traditional teaching methods.

In the creative arts and design fields, VR tools like Tilt Brush and Gravity Sketch are transforming creative arts and design education by enabling students to sketch and prototype directly in three-dimensional space. Stephen and Kunnumpurath (2024) conclude that incorporating Tilt Brush into architecture curricula significantly enhances students' creative output and spatial visualization skills. The authors indicate that none of the participants fell below the "Satisfactory" threshold, and 80% reached "Accomplished" levels of creativity, indicating that VR-based 3D painting fosters both the creative process and the final design quality. Tools like Tilt Brush help develop key design skills include thinking creatively, using 3D technology, and evaluating one's own work. In another study, Lin et al. (2022) observed that when design students used Gravity Sketch in VR, they produced significantly fewer sketches and spent more time on each than when sketching on paper; The authors note that the three-dimensional, clear environment helps puppils focus on detailed improvements instead of rushing ideas. This shows that VR sketching works better in the later stages of the design process (Lin et al., 2022).

6. Trends and Key Findings

Several broader trends can be discerned from a close examination of the specialized AI and VR tools cataloged in higher education, revealing insights into licensing models, technical requirements, cost structures, integration approaches, disciplinary focus, hardware dependencies, and the growing convergence of artificial intelligence (AI) and virtual reality (VR).

First, the analysis confirms a strong market preference for proprietary solutions: nearly 91% of tools operate under paid licenses. This dominance stems from the significant R&D investments needed to develop the AI algorithms, immersive 3D simulations, and scalable platform architectures. Furthermore, proprietary vendors also fund dedicated support teams that provide ongoing support and regular updates, as well as features that are unavailable in open-source alternatives, which are also limited in number. These characteristics are crucial for institutions that cannot manage the technical and staffing costs of developing solutions in-house. Nevertheless, open-source alternatives occupy important niche applications, particularly in VR education. For example, OpenSimulator demonstrates how customizable open-source options enable teachers to create virtual experiences tailored to their learning goals, offering flexibility that proprietary solutions may not provide. Additionally, institutions using open-source solutions can maintain full control over data privacy and deployment.

Second, technical complexity, defined here as the combination of infrastructure, software dependencies, and user expertise required for deployment, predominantly falls into the "medium" category. Approximately 49% of the surveyed tools are considered medium complexity, meaning they necessitate some level of server-side setup (e.g., cloud hosting, database configuration), instructor training, and potentially limited hardware provisioning. Equally, nearly 42% are rated "low" complexity, typically browser-based AI quiz platforms or lightweight VR applications that run on standard laptops or mobile devices without specialized peripherals. Only around 9% of tools are classified as "high" complexity—those requiring advanced knowledge of programming, custom hardware such as high-end motion capture rigs, or extensive IT support. Vendors are working to

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balance features that are advanced with interfaces that are easy to use. They are also focusing on seamless integration since many educators may not have strong technical skills. There is an ongoing trend toward ecosystem-based educational design, in which modular AI and VR tools are designed for interoperability through APIs, Learning Tools Interoperability (LTI) standards, SDKs, and cloud-based platforms. These integration pathways support unified digital infrastructures that facilitate easy-to-use and maintainable unified infrastructure.

Third, cost models remain dominated by subscription pricing, which applies to approximately 45% of AI-driven and VR-enhanced tools. Subscription models allow vendors to deliver continuous updates—particularly vital for AI platforms that require regular retraining of algorithms on new data—and to provide ongoing technical support. This approach ensures that the software remains current with evolving pedagogical standards, security protocols, and cloud infrastructure changes. Aside from pure subscription, around 29.9% of tools utilize a freemium model, wherein basic functionality is accessible at no cost, while advanced features are unlocked through paid tiers. Pure enterprise licensing, accounting for roughly 12%, typically involves institution-wide agreements. Although a one-time purchase model exists—especially for standalone VR experiences—it is relatively rare, as the need for frequent AI model updates and virtual environment enhancements has made recurring revenue structures more sustainable for providers.

Fourth, integration capability remains a critical differentiator among these tools. Approximately 22% of platforms operate as standalone solutions, requiring no integration with existing campus software. This makes them attractive to smaller institutions that want simple, easy-to-use options. However, the data reveal that about 16 % of tools offer pure LMS integration, while another 21 % combine LMS connectivity with API access (e.g., Gradescope), enabling single sign-on, gradebook synchronization, and continuous data exchange. Only around 6 % of tools provide full LMS + API + cloud integration (e.g., Canvas, Brightspace), supporting advanced use cases such as real time adaptive learning pathways informed by campus wide data warehouses. These hybrid models directly address institutional demands for cohesive digital ecosystems over isolated silos. As universities prioritize centralized data strategies, tools with API-driven and cloud-enabled integration layers will likely see accelerated adoption.

Fifth, the tools' disciplinary focus reveals a clear preference for general-purpose solutions: nearly 70% of platforms are designed to serve all academic disciplines. These hybrid integration models address the growing institutional desire for cohesive digital learning ecosystems rather than isolated educational silos. As universities chart roadmaps for centralized student data warehouses and unified dashboards, integration-ready tools will likely see accelerated adoption.

These include generic LMSs, data analytics suites, and broad VR meeting spaces that can be repurposed for various use cases, from virtual labs to interactive seminars. The remaining 30% are more narrowly targeted, with only a handful of examples catering exclusively to fields such as medical and health sciences (e.g., surgical simulators), STEM (e.g., virtual chemistry labs), or arts and design (e.g., VR painting studios). This distribution suggests that while specialized tools do exist to address domain-specific pedagogical nuances, many institutions derive sufficient value from adaptable, cross-disciplinary platforms that can be customized via plugins or API-driven extensions. For programs that require deep domain fidelity, investing in bespoke solutions remains necessary. Institutions may prefer to try out general options first because the initial cost and maintenance can be high when working with specialized vendors.

Sixth, hardware dependency is a vital factor affecting adoption and scalability. A substantial majority, about 67 %, of AI-based tools operate entirely in the cloud or are browser-based, meaning they require no specialized hardware beyond standard laptops, tablets, or smartphones. This architecture significantly lowers barriers to entry, especially for institutions with limited technology budgets. Conversely, roughly 17.9% of tools necessitate dedicated VR headsets (e.g., Oculus Rift, HTC Vive), and another 9.0% require mixed-reality (MR/AR) devices such as Microsoft HoloLens. These immersive platforms, although highly engaging, introduce substantial capital and logistical costs: procurement of headsets, provision of compatible workstations or standalone devices, and the

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need for dedicated lab space with motion-tracking sensors. Nonetheless, the rapid evolution of standalone VR headsets (e.g., Meta Quest series), which combine wireless freedom with sufficient graphical fidelity, has driven hardware costs, making it feasible to equip entire classrooms.

Finally, there is an emergence of hybrid solutions that combine AI and VR. Approximately 13% of the tools explicitly combine AI and VR technologies. Hybrid AI-VR solutions in higher education provide a modern way to learn by combining the best features of both technologies. This partnership creates benefits that each technology alone cannot deliver. However, developing and integrating these hybrid platforms will require more expertise and make integration more difficult and expensive, driving up both initial development costs and ongoing staffing needs. As digital-twin campus initiatives gain traction, we can expect richly detailed virtual replicas of real-world institutions to redefine hybrid and remote education.

In summary, the landscape of specialized AI and VR tools in higher education is characterized by a dominance of proprietary, subscription-based models; a deliberate balance of technical complexity to facilitate educator adoption; a reliance on standalone solutions for immediate usability; and an increasingly common embrace of all-disciplinary platforms. However, some open-source alternatives offer cost-effective customization. Integration-ready tools are responding to the push for ecosystem coherence, and convergent AI and VR platforms are setting new benchmarks for immersive, personalized learning. As hardware costs decline and cloud infrastructure matures, institutions can expect continued evolution toward end-to-end, AI-driven immersive environments—transforming how knowledge is delivered, assessed, and internalized across the academic spectrum.

7. Ethical Considerations

The integration of the tools in education holds significant potential but has generated numerous ethical considerations that are becoming increasingly critical as these tools are adopted more widely. As these technologies increasingly shape learning environments, institutions must address concerns related to data privacy, algorithmic fairness inclusivity, academic integrity, transparency, accountability, and the potential over-reliance on technology to ensure that innovation remains aligned with educational values and human dignity.

One major ethical concern is data governance and privacy, as it is well known that these systems, particularly AI systems, collect vast amounts of student data. There is concern in the academic sphere that this data can be used for surveillance and other malignant ways. For example, Adiguzel et al. (2023) stress the importance of giving students more control over their data. They suggest that educational platforms should have clear ways for students to opt in and should provide straightforward information about how their data will be used. Recognizing this problem, policymakers are attempting to provide guidelines, with bodies like the European Parliamentary Research Service dictating that transparency and explainability are essential ethical pillars in AI, particularly when such systems influence human development and decision-making, as in education (Sartor & Lagioia, 2020). Therefore, EU proposes that institutions must therefore adhere to robust data protection frameworks, such as the General Data Protection Regulation (GDPR), which sets a global benchmark for handling data of EU residents, regardless of the institution's physical location. A core requirement of GDPR, and similar regulations inspired by it, is clear communication regarding how AI applications operate and the decision-making processes involved is essential for accountability and trust (Balta, 2023; Weidener & Fischer, 2024).

Equally pressing is the issue of algorithmic bias. Since AI algorithms learn patterns directly from the data they are trained on, the quality of that data is fundamental. When AI algorithms are trained on narrow or unrepresentative datasets, they may unintentionally reinforce existing inequities, particularly in assessment and predictive analytics (Owan et al., 2023). For example, if the datasets lack diversity, the AI may fail to accurately evaluate the decision-making of people who were underrepresented in the dataset. This can disadvantage individuals from those groups, making it harder for them to succeed.

Academic integrity is a significant ethical challenge increasing with the proliferation of generative AI. AI tools can inadvertently promote plagiarism, especially given indications that many students lack formal guidance on ethical writing practices in this context (Pan, 2024a). Zhou, Zhang, and Chan (2024) similarly stress that unchecked AI use not only raises significant ethical challenges, but also highlight concerns about over-reliance on AI that potentially that will compromise original thinking and critical analysis. Wiredu, Abuba, and Zakaria (2024) also highlight the importance of deploying advanced plagiarism and generative-AI detection tools alongside AI literacy programmes. However, some studies propose that rather than focusing solely on detection, educational institutions should adopt a more holistic approach to AI in education. According to Kumar (2023), traditional methods, which rely heavily on artifacts such as essays, need to evolve into more robust, AI-aware forms of assessment that genuinely reflect student learning and skills, rather than relying heavily on artifacts such as essays. Finally, AI threatens the sustainability of meaningful educational experiences, particularly regarding the irreplaceable role of human educators (Okulich-Kazarin et al., 2024). Having considered these multifaceted ethical risks, attention must now turn to the construction of a coherent ethical model—capable of ensuring that innovation in AI supports rather than supplants human-centred education.

The ethical paradigm articulated by Smyrnaiou et al. (2023), situated within the broader vision of Education 5.0, provides a compelling call for human-centric, responsible, and equitable technological integration. This paper embraces that vision while also proposing a complementary, multi-layered ethical framework, grounded in empirical findings from the present study. The audit of AI and VR tools conducted as part of this research, documented in the accompanying Excel dataset, indicates that while some platforms include ethical compliance features such as privacy controls, accessibility standards, and bias mitigation protocols, available information was often limited or inconsistently disclosed. In most cases, vendor responses were not forthcoming in the efforts to obtain further documentation or access to the software, thereby constraining the evaluative depth of the audit.

This finding shows the need to include ethical safeguards right from the start of the design process and throughout deployment. To effectively address these complex issues, stakeholders must work together to create detailed curricula, frameworks and educational pipelines. Such frameworks must champion diversity, support broad intellectual engagement, and maintain human agency over technology to ensure that generative AI tools enhance rather than restrict educational experiences (Rudolph et al., 2023).

7. Challenges and Opportunities

The use of these tools in higher education presents transformative opportunities alongside complicated challenges. While promising to revolutionize learning, democratize access, and deepen engagement, successful adoption demands more than technical upgrades; it requires a fundamental rethinking of infrastructure, pedagogy, and institutional culture.

First, a strong technical infrastructure serves as the essential foundation for successful implementation. For example, these tools require institutions to have strong infrastructure, including fast internet connections, powerful servers, and VR headsets. Furthermore, if any AI model training or VR development is needed on-premise, it requires costly GPU infrastructure. These needs can challenge the budgets of smaller colleges. Integrating these technologies with existing LMS adds more complexity.

To successfully integrate AI and VR tools, institutional systems must work seamlessly together. This demands not only effective data sharing and clear communication between platforms but also robust cybersecurity measures to safeguard against breaches and maintain data integrity. Moreover, institutions must navigate a complex regulatory landscape, balancing innovation with compliance, as previously discussed in ethical considerations, while ensuring these technical foundations remain resilient. Failure to address these requirements inevitably erodes student trust and institutional credibility. Additionally, these deficiencies manifest acutely in user experience. Inadequate bandwidth disrupts learning continuity, while unresolved technical and physiological barriers, particularly VR sickness affecting a substantial user cohort, demand proactive mitigation. Empirical classroom studies underscore these barriers: connectivity issues frequently interrupt sessions, while VR-induced dizziness compromises focus and accessibility (Domínguez Vázquez and Díaz Palencia, 2024).

These technical limitations directly contradict Cabrera-Duffaut et al.'s (2024) mandate that VR must complement pedagogy, a principle further challenged when technical failures undermine accessibility. Overcoming these barriers alone is insufficient; VR and AI tools cannot intrinsically enhance learning without deliberate pedagogical alignment.

Tools alone do not guarantee better results. Educators need to align them with sound pedagogical theories and practices and avoid superficial use. This demands extensive faculty training and curriculum redesign. For example, Han et al. (2022) demonstrate that VR content selection requires pedagogical strategic alignment between immersion levels and perspective-taking designs to maximize empathy. Meanwhile, empirical evidence has demonstrated that cognitive load in VR environments (Huang et al., 2019) and institutional resistance driven by resource limitations and digital divides to disrupt traditional methods (Cedeño et al., 2024) pose additional hurdles. Without the pedagogical context, these tools risk becoming distractions rather than enhancements.

Successful integration requires robust infrastructure and effective pedagogy, as discussed in the previous section, but these alone are insufficient. Equally critical are supportive institutional culture and strategic planning. Without these, faculty resistance, often stemming from fears of job displacement and digital skill gaps, becomes a significant barrier to adoption. Institutions also grapple with long-term costs, ethical dilemmas around AI decisions, and the urgent need for teacher professional development in emerging technologies (Rudnik, 2022). Financial constraints further complicate scaling efforts (Sila et al., 2023), while ethical concerns, such as data privacy, as already discussed in the ethical consideration section, and demand careful navigation. These challenges are connected: if schools do not invest in training, teachers cannot overcome technical and teaching barriers.

8. Opportunities for Innovation

Current educational landscapes, while benefiting from isolated implementations of AI-driven analytics and VR-based simulations, have yet to fully leverage the potential of combining these technologies into cohesive, interactive ecosystems (Li and Rohayati, 2025). The rapid increase in the use of these tools in education necessitates an understanding of development trends for technological innovations and their implementation in higher education. To bridge this knowledge gap, the establishment of specialized laboratories or dedicated spaces where these technologies can be practically explored and refined should be encouraged. These labs will reshape institutional approaches to student engagement and pedagogical effectiveness. These specialized labs would provide the necessary environment to develop the next generation of adaptive learning engines, moving beyond current limitations. Existing adaptive learning systems, such as Knewton Alta and ALEKS, currently rely on predefined adaptive algorithms. The integration of machine learning, as indicated by Xu (2022), real-time vocabulary adaptation, serves as a foundational approach to develop more intelligent systems. However, the opportunity exists for even more sophisticated, real-time adaptive engines. For instance, the analysis of eye movements in VR training can help identify moments of difficulty and provide support, leading to more effective personalized learning (Hong et al., 2021). The authors experimented with 21 participants in VR training and demonstrated the utility of eye-tracking data in identifying moments for intervention. Such advancements, which can also integrate the analysis of other observed behaviors (Slater et al., 2022), enable the creation of genuinely personalized learning paths that enhance learner engagement and educational outcomes (Chalkiadakis et al., 2024). Achieving these enhanced educational outcomes through advanced technological integration, however, extends beyond pedagogical tools to fundamentally reshape institutional approaches to learning.

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Integrating technology effectively enhances efficiency and sparks creativity and innovation, the core of education alongside critical thinking and problem-solving. Zlatanović et al. (2020) emphasize the necessity of a systemic approach to improve innovativeness in higher education, which is crucial for cultivating a creative learning environment that fosters the skills mentioned above, as well as risk-taking and learning from failure.

Building on this foundation of innovative learning environments, the potential of AI and VR tools in career readiness is significant, especially since AI is already disrupting the workforce. Acknowledging their importance, 70% of community college students are actively working to enhance their readiness for careers in AI (Campus Technology, 2025). VR, on the other hand, may not disrupt the workforce but can serve as a tool for career adaptability via the skill-based learning it offers. Indeed, immersive VR training has been shown to significantly enhance career adaptability through experiential learning and effective career decision-making in an evolving job market (Korniienko & Barchi, 2025).

Concluding, to fully use the potential of AI and VR tools in preparing students for a changing workforce as well as in academia, schools need to innovate and integrate these technologies effectively. These systematic processes can be facilitated by holistic frameworks that provide guidelines for the full spectrum of integration and pedagogical alignment. These frameworks should be easy to scale and adapt across universities. Although specific frameworks are still under development, hinting at their eventual application can encourage institutions to consider strategic preparation for these impending integrations.

9. Conclusions and Future Work

Bringing AI and VR into higher education it is a significant leap towards Education 5.0. The need for an efficient integration will require frameworks that truly weave these powerful technologies into teaching practices. However, several critical hurdles remain as described in this paper, such as data privacy, algorithm fairness, the digital equality gap, and adequate training for educators. To address these challenges, there is a need for practical solutions that must be flexible enough to make education more effective and inclusive.

Future research should focus on the practical implementation of testing how well AI and VR improve synergistically student learning and engagement over time. Improving how these technologies respond to learners through real-time data analysis and simpler user interactions is essential. Pilot programs that closely resemble real classroom or lab settings can provide proof of their effectiveness. The results can help improve integration procedures before they are rolled out more widely. Training programs for teachers will help them effectively use these new tools, backed by transparent ethical standards. Finally, collaboration across institutions and disciplines will expand the possibilities and accessibility.

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Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial Intelligence
AI-VR	Artificial Intelligence–Virtual Reality (combined or hybrid technology)

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API	Application Programming Interface
DCCI	Dynamic Course Content Integration
Education 5.0	The fifth generation of education emphasizing personalization and technological integration
FERPA	Family Educational Rights and Privacy Act
GDPR	General Data Protection Regulation
GPU	Graphics Processing Unit
LMS	Learning Management System
NLP	Natural Language Processing
VR	Virtual Reality

Appendix A

This appendix provides a descriptive overview of the dataset of 68 Artificial Intelligence (AI), Virtual Reality (VR), and hybrid AI-VR tools analysed in this study. Due to the large size of the dataset, the complete table is provided online and can be accessed at the following link:

Full Dataset (Supplementary Appendix A): https://1drv.ms/x/c/9fff3e766e9a1e80/EUqwMA5zufJPr6hwaNY-FPkB89u1joNMlHklNqJC0waUsw?e=3MmoM8

The dataset contains detailed information on each tool, including technological category, purpose, cost model, integration capabilities, and ethical considerations. The structure of the dataset is as follows:

- **Column A – Tool / Platform:**
  The name of the AI, VR, or hybrid tool.
- **Column B – AI/VR Balance:**
  Classification as AI, VR, or AI-VR Hybrid.
- **Column C – Purpose/Functionality:**
  The primary functional use of the tool (e.g., tutoring, simulation, automated assessment).
- **Column D – Technical Complexity:**
  Implementation difficulty (Low, Medium, High).
- **Column E – Cost Model:**
  Free, Freemium, Institutional Licence, or Commercial pricing.
- **Column F – Integration Capability:**
  The ability to integrate with other systems
- **Column G – Target Discipline:**
  The academic field(s) where the tool is intended to be used.
- **Column H – Target Audience:**
  The primary users of the tool
  Column I – Accessibility Features:
  Accessibility accommodations provided by the tool
- **Column J – Hardware Dependency:**
  Any required physical equipment or technical infrastructure
  (e.g., VR headsets, high-performance GPU, smart devices).
- **Column K – Open Source vs. Proprietary:**
  Indicates whether the tool is open-source, proprietary.
- **Column L – Ethical/Privacy Compliance:**
  Information on how the tool adheres to ethical, legal, and privacy frameworks
- **Column M – Site:**
  The tool's primary website or documentation link.

Below is a sample extract with five representative tools from the full dataset:

Tool/Platform	Type	Purpose/Functionality	Target Discipline	Reference /Site
Alchemy	AI	Faculty-support platform for educators	All disciplines	alchemy.works
ALEKS	AI	Adaptive learning system	STEM (Math)	aleks.com
AnatomyX	XR	AR-based anatomy education	Medical & Health Sciences	anatomyx.com
Axon Park	AI-VR	Immersive educational platform	All disciplines	axonpark.com
Blackboard	AI	Learning-management system	All disciplines	anthology.com
…	…	…	…	…

References

(Adiguzel et al., 2023) Adiguzel, T., Kaya, M.H., & Cansu, F.K. (2023). Revolutionizing education with AI: Exploring the transformative potential of ChatGPT. *Contemporary Educational Technology*, *15*(3), ep429. https://doi.org/10.30935/cedtech/13152

(Baker, 2016) Baker, R. (2016). Stupid tutoring systems, intelligent humans. *International Journal of Artificial Intelligence in Education*, *26*(2), 600–614. https://doi.org/10.1007/s40593-016-0105-0

(Balta, 2023) Balta, N. (2023). Ethical considerations in using AI in educational research. *Journal of Research in Didactical Sciences*, *2*(1), Article 14205. https://doi.org/10.51853/jorids/14205

(Bernhardt-Walther & McKeown, 2023) Bernhardt-Walther, K., & McKeown, R.J. (2023). The impact of ALEKS on student learning in first-year university mathematics for economics [Online]. Available online: https://www.robertjmckeown.com/uploads/ALEKS_McKeown.pdf (accessed on 14 July 2025).

(Bulut et al., 2024) Bulut, O., Beiting-Parrish, M., Casabianca, J.M., Slater, S.C., Jiao, H., Song, D., Ormerod, C.M., Fabiyi, D.G., Ivan, R., Walsh, C., Rios, O., Wilson, J., Yildirim-Erbasli, S.N., Wongvorachan, T., Liu, J.X., Tan, B., & Morilova, P. (2024). The rise of artificial intelligence in educational measurement: Opportunities and ethical challenges. *arXiv* [Preprint]. Available online: https://arxiv.org/abs/2406.18900 (accessed on 21 May 2025).

(Campus Technology, 2025) Campus Technology (2025, April 11). 70% of community college students are working to improve AI career readiness, despite mixed feelings about AI. *Campus Technology*. Available online: https://campustechnology.com/articles/2025/04/11/70-of-community-college-students-are-working-to-improve-ai-career-readiness.aspx (accessed on 12 June 2025).

(Cabrera-Duffaut et al., 2024) Cabrera-Duffaut, J., et al. (2024). Augmented and virtual reality in U.S. education: A review—Analyzing the impact, effectiveness, and future prospects of AR/VR tools in enhancing learning experiences [Online]. *ResearchGate*. Available online: https://www.researchgate.net/publication/379921418_AUGMENTED_AND_VIRTUAL_REALITY_IN_US_EDUCATION_A_REVIEW_ANALYZING_THE_IMPACT_EFFECTIVENESS_AND_FUTURE_PROSPECTS_OF_ARVR_TOOLS_IN_ENHANCING_LEARNING_EXPERIENCES (accessed on 14 July 2025).

(Caroline et al., 2023) Caroline, C., Oroh, O., & Pada, D. (2023). Enhancing online learning experiences through personalization utilizing recommendation algorithms. *International Journal of Software Engineering and Computer Science*, *3*(3), 398–407. https://doi.org/10.35870/ijsecs.v3i3.1852

(Cedeño et al., 2024) Cedeño, M., Figueroa, M., Humanante, P., & Monroy, W. (2024). Analysis of the application of artificial intelligence in technical and technological training in university education. *Revista de Gestão Social e Ambiental*, *18*(4), e07087. https://doi.org/10.24857/rgsa.v18n4-145

CENTURY Tech (2024). Introduction to CENTURY [Online]. Available online: https://support.century.tech/support/solutions/articles/44001898928-introduction-to-century (accessed on 18 May 2025).

CENTURY Tech (2025). Transforming education in Liverpool: Pilot between Liverpool City Region and CENTURY delivers 10% learning gains for 4,000 students while saving 1,800 teacher hours [Online]. Available online: https://www.century.tech/news/transforming-education-in-liverpool-pilot-between-liverpool-city-region-and-century-delivers-10-learning-gains-for-4000-students-while-saving-1800-teacher-hours/ (accessed on 18 May 2025).

(Chalkiadakis et al., 2024) Chalkiadakis, A., Seremetaki, A., Kanellou, A., Kallishi, M., Morfopoulou, A., Moraitaki, M., & Mastrokoukou, S. (2024). Impact of artificial intelligence and virtual reality on educational inclusion: A systematic review of technologies supporting students with disabilities. *Education Sciences*, *14*, 1223. https://doi.org/10.3390/educsci14111223

(Chaurasiya, 2024) Chaurasiya, P. (2024). Studynotion – an edtech website. *International Journal of Scientific Research in Engineering and Management*, *8*(5), 1–5. https://doi.org/10.55041/ijsrem33031

(D2L, 2025) D2L (2025). Introducing new Brightspace generative AI capabilities [Online]. *D2L Community*. Available online: https://community.d2l.com/brightspace/kb/articles/26141-introducing-new-brightspace-generative-ai-capabilities (accessed on 19 May 2025).

(DigitalDefynd, 2025) DigitalDefynd (2025). 10 challenges of AR VR in education and how to overcome [Online]. Available online: https://digitaldefynd.com/IQ/ar-vr-in-educating-teaching/ (accessed on 4 July 2025).

Digital Promise (2020). Time to mastery in adaptive learning [Online]. Available online: https://www.numberanalytics.com/blog/top-7-intelligent-adaptive-learning-systems-education-success (accessed on 23 May 2025).

(Domínguez Vázquez & Díaz Palencia, 2024) Domínguez Vázquez, B.C., & Díaz Palencia, J.L. (2024). A classroom experience for teaching and learning of high school geometry through virtual reality. *Pedagogical Research*, *9*(3), em0210. https://doi.org/10.29333/pr/14634

(ENGAGE XR, n.d.) ENGAGE XR (n.d.). AI – ENGAGE XR [Online]. Available online: https://engagevr.io/ai/ (accessed on 22 May 2025).

(European Parliament et al., 2020) European Parliament, Directorate-General for Parliamentary Research Services, Lagioia, F., & Sartor, G. (2020). The impact of the General Data Protection Regulation on artificial intelligence. *Publications Office of the European Union*: Luxembourg. Available online: https://data.europa.eu/doi/10.2861/293 (accessed on 5 July 2025).

(Febrianti et al., 2024) Febrianti, M., Rahmawati, I.N., Aisyah, & Putra, A.K. (2024). Using the Duolingo application as a vocabulary learning tool in higher education. *International Journal of Lingua and Technology*, *3*(2), 345–361. Available online: https://www.researchgate.net/publication/384061426_Using_the_Duolingo_Application_as_a_Vocabulary_Learning_Tool_in_Higher_Education (accessed on 20 May 2025).

(Fundamental VR, 2019) Fundamental VR (2019). Validation of the Fundamental Surgery Orthopaedic Simulation for P-THR [White paper]. Available online: https://fundamentalsurgery.com/wp-content/uploads/2019/03/FundamentalVR_ValidationFeb2019_BOTA.pdf (accessed on 21 May 2025).

(Han et al., 2022) Han, I., Shin, H., Ko, Y., & Shin, W. (2022). Immersive virtual reality for increasing presence and empathy. *Journal of Computer Assisted Learning*, *38*(4), 1115–1126. https://doi.org/10.1111/jcal.12669

(Hattie et al., 2021) Hattie, J., Crivelli, J., Van Gompel, K., West-Smith, P., & Wike, K. (2021). Feedback that leads to improvement in student essays: Testing the hypothesis that "where to next" feedback is most powerful. *Frontiers in Education*, *6*, 645758. https://doi.org/10.3389/feduc.2021.645758

(Hong et al., 2021) Hong, S., Shin, H., Gil, Y., & Jo, J. (2021). Analyzing visual attention of people with intellectual disabilities during virtual reality-based job training. *Electronics*, *10*, 1652. https://doi.org/10.3390/electronics10141652

(Hubbell, 2021) Hubbell, K. (2021). Design evidence-based learning experiences [White paper]. Sana Labs. Available online: https://sanalabs.com/download/KenHubbellRoundtableWhitePaper.pdf (accessed on 21 May 2025).

(Huang et al., 2019) Huang, C., Luo, Y., Yang, S., Lu, C., & Chen, A. (2019). Influence of students' learning style, sense of presence, and cognitive load on learning outcomes in an immersive virtual reality learning environment. *Journal of Educational Computing Research*, *58*(3), 596–615. https://doi.org/10.1177/0735633119867422

(Ivanov et al., 2023) Ivanov, M., Cristea, D., Vlase, M., & Munteanu, D. (2023). Navigating learning paths with Edsense: An AI-powered learning platform. *JDP*, *2*(1), 14–24. https://doi.org/10.61071/jdp.2375

(Jiang et al., 2022) Jiang, X., Rollinson, J., Plonsky, L., Gustafson, E., & Pajak, B. (2022). Evaluating the reading and listening outcomes of beginning-level Duolingo courses. *Foreign Language Annals*, *54*(4), 974–1002. https://doi.org/10.1111/flan.12600

(Kerssens, 2023) Kerssens, N. (2023). Schooled by dashboards? Learning platforms' performance-centered pedagogy and its impact on teaching. In *Learning Platforms and the European Educational Space* (pp. 241–254). https://doi.org/10.1515/9789048555444-016

(Korniienko & Barchi, 2025) Korniienko, I., & Barchi, B. (2025). Enhancing career adaptability through immersive virtual reality training. *Scientific Bulletin of Mukachevo State University. Series "Pedagogy and Psychology"*, *11*(1), 41–50. https://doi.org/10.52534/msu-pp1.2025.41

(Kumar et al., 2023) Kumar, R., Eaton, S.E., Mindzak, M., & Morrison, R. (2023). Academic integrity and artificial intelligence: An overview. In *Handbook of Academic Integrity and Artificial Intelligence* (pp. 1–14). https://doi.org/10.1007/978-981-287-079-7_153-1

(Kyaw et al., 2019) Kyaw, B.M., Saxena, N., Posadzki, P., Vseteckova, J., Nikolaou, C.K., George, P.P., Divakar, U., Masiello, I., Kononowicz, A.A., Zary, N., & Car, L.T. (2019). Virtual reality for health professions education: Systematic review and meta-analysis by the Digital Health Education Collaboration. *Journal of Medical Internet Research*, *21*(1), e12959. https://doi.org/10.2196/12959

(Li & Rohayati, 2025) Li, M., & Rohayati, M.I. (2025). A bibliometric analysis of artificial intelligence applications in global higher education. *International Journal of Information System Modeling and Design*, *16*(1), 1–24. https://doi.org/10.4018/IJISMD.365913

(Lin et al., 2022) Lin, M.-H., Chiang, I.-C., Lee, L., & Lu, H.-X. (2022). Examining performance of VR sketch modeling tool in personal sketches. In D. Lockton, S. Lenzi, P. Hekkert, A. Oak, J. Sádaba, & P. Lloyd (Eds.), *DRS2022: Bilbao, 25 June – 3 July, Bilbao, Spain*. https://doi.org/10.21606/drs.2022.200

(Lindner et al., 2024) Lindner, M., Leutritz, T., Backhaus, J., König, S., & Mühling, T. (2024). Knowledge gain and the impact of stress in a virtual reality-based medical emergencies training with automated feedback – a randomized controlled trial [Preprint]. JMIR Preprints. https://doi.org/10.2196/preprints.67412

(Liu et al., 2023) Liu, J.Y.W., Yin, Y.H., Kor, P.P.K., Cheung, D.S.K., Zhao, I.Y., Wang, S., Su, J.J., Christensen, M., Tyrovolas, S., & Leung, A.Y.M. (2023). The effects of immersive virtual reality applications on enhancing the learning outcomes of undergraduate health care students: Systematic review with meta-synthesis. *Journal of Medical Internet Research*, *25*, e39989. https://doi.org/10.2196/39989

(McGraw Hill Education, n.d.) McGraw Hill Education (n.d.). ALEKS case study: Texas A&M University, College Station, TX [Online]. Available online: https://www.mheducation.com/unitas/highered/discipline/chemistry/aleks-case-study-chem-am-collins.pdf (accessed on 14 July 2025).

(Medivis, 2019) Medivis (2019). AnatomyX platform description [Online]. Available online: https://www.medivis.com/anatomyx (accessed on 12 July 2025).

(MMD, 2021) MMD (2021). Civitas Learning: Using data to improve student success [Online]. *Digital Innovation and Transformation, Harvard Business School Digital Initiative*, 22 March. Available online: https://d3.harvard.edu/platform-digit/submission/civitas-learning-using-data-to-improve-student-success/ (accessed on 21 May 2025).

 doi:10.20944/preprints202601.1173.v1

(Mukasa, 2021) Mukasa, C. (2021). Work in progress: Plagiarism detection in first-year programming coursework [Conference paper]. *American Society for Engineering Education*. *Available online*: https://peer.asee.org/38399 (accessed on 20 May 2025).

(Mzwri & Turcsányi-Szabo, 2025) Mzwri, K., & Turcsányi-Szabo, M. (2025). Bridging LMS and generative AI: Dynamic course content integration (DCCI) for connecting LLMs to course content – the Ask ME Assistant. *arXiv [Preprint]*. https://doi.org/10.48550/arXiv.2504.03966

(Nagaraj, 2023) Nagaraj, B. (2023). The emerging role of artificial intelligence in STEM higher education: A critical review. *International Research Journal of Multidisciplinary Technovation*, 1–19. https://doi.org/10.54392/irjmt2351

(Okulich-Kazarin et al., 2023) Okulich-Kazarin, V., Skowron, Ł., Artyukhov, A., Dluhopolskyi, O., & Cwynar, W. (2023). Sustainability of higher education: Study of student opinions about the possibility of replacing teachers with AI technologies. *Sustainability*, 16(1), 55. https://doi.org/10.3390/su16010055

(Online Learning Consortium, 2021) Online Learning Consortium. (2021). Adaptive course completion rates. *Available online*: https://www.numberanalytics.com/blog/top-7-intelligent-adaptive-learning-systems-education-success (accessed on 23 May 2025).

(OECD, 2024) Organisation for Economic Co-operation and Development (OECD). (2024). The potential impact of artificial intelligence on equity and inclusion in education. *OECD Artificial Intelligence Papers, No. 23*. OECD Publishing: Paris. *Available online*: https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/08/the-potential-impact-of-artificial-intelligence-on-equity-and-inclusion-in-education_0d7e9e00/15df715b-en.pdf (accessed on 5 July 2025).

(Osso VR, 2022) Osso VR. (2022). Research continues to support the benefits of Osso VR for surgical training, 21 September. *Available online*: https://www.ossovr.com/post/research-continues-to-support-the-benefits-of-osso-vr-for-surgical-training (accessed on 21 May 2025).

(Owan et al., 2023) Owan, V.J., Abang, K.B., Idika, D.O., Etta, E.O., & Bassey, B.A. (2023). Exploring the potential of artificial intelligence tools in educational measurement and assessment. *EURASIA Journal of Mathematics, Science and Technology Education*, 19(8), em2307. https://doi.org/10.29333/ejmste/13428

(Ouyang & Jiao, 2021) Ouyang, F., & Jiao, P. (2021). Artificial intelligence in education: The three paradigms. *Computers and Education: Artificial Intelligence*, 2, 100020. https://doi.org/10.1016/j.caeai.2021.100020

(Pan, 2024a) Pan, J. (2024). AI-driven English language learning program and academic writing integrity in the era of intelligent interface. *English Language Teaching and Linguistics Studies*, 6(4), p120. https://doi.org/10.22158/eltls.v6n4p120

(Pan, 2024b) Pan, S. (2024). Research on teaching strategies of immersive experiential teaching for collaborative learning in elementary and middle schools based on AI and VR. *Advances in Educational Technology and Psychology*, 8(5). https://doi.org/10.23977/aetp.2024.080503

(Paradiso Solutions, 2025) Paradiso Solutions. (2025). Best AI-powered tools for LMS: Smarter learning in 2025. *Available online*: https://www.paradisosolutions.com/blog/best-ai-powered-tools-for-lms/ (accessed on 4 July 2025).

(Radianti et al., 2020) Radianti, J., Majchrzak, T.A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. *Computers & Education*. *Available online*: https://www.sciencedirect.com/science/article/pii/S0360131519303276 (accessed on 21 May 2025).

(Rudnik, 2022) Rudnik, Y. (2022). Teacher students training to implement AR and VR technologies in foreign language teaching. *The Modern Higher Education Review*, 7, 99–110. https://doi.org/10.28925/2518-7635.2022.78

(Rudolph et al., 2023) Rudolph, J., Tan, S., & Tan, S. (2023). ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? *Journal of Applied Learning & Teaching*, 6(1), 342–359. https://doi.org/10.37074/jalt.2023.6.1.9

(Sartor & Lagioia, 2020) Sartor, G., & Lagioia, F. (2020). The impact of the General Data Protection Regulation (GDPR) on artificial intelligence. *European Parliamentary Research Service*. *Available online*:

https://www.europarl.europa.eu/RegData/etudes/STUD/2020/641530/EPRS_STU(2020)641530_EN.pdf (accessed on 13 July 2025).

(Sila et al., 2023) Sila, C.A., William, C., Yunus, M.M., & Rafiq, K.R.M. (2023). Exploring students' perception of using ChatGPT in higher education. *International Journal of Academic Research in Business and Social Sciences*, 13(12). https://doi.org/10.6007/ijarbss/v13-i12/20250

(Skinner, 1958) Skinner, B.F. (1958). Teaching machines. *Science*, 128(3330), 969–977.

(Slater et al., 2022) Slater, M., Banakou, D., Beacco, A., Gallego, J., Macía-Varela, F., & Oliva, R. (2022). A separate reality: An update on place illusion and plausibility in virtual reality. *Frontiers in Virtual Reality*, 3, 914392. https://doi.org/10.3389/frvir.2022.914392

(Smith et al., 2024) Smith, B., Jiang, X., & Peters, R. (2024). The effectiveness of Duolingo in developing receptive and productive language knowledge and proficiency. *Language Learning & Technology*, 28(1), 1–26. *Available online*: https://www.lltjournal.org/item/10125-73595/ (accessed on 15 June 2025).

(Smyrnaiou et al., 2023) Smyrnaiou, Z., Liapakis, A., & Bougia, A. (2023). Ethical use of artificial intelligence and new technologies in Education 5.0. *Journal of Artificial Intelligence, Machine Learning and Data Science*, 1(4), 119–124. *Available online*: https://www.researchgate.net/publication/374681720_Ethical_Use_of_Artificial_Intelligence_and_New_Technologies_in_Education_50 (accessed on 20 June 2025).

(Stavroulia & Lanitis, 2019) Stavroulia, K.E., & Lanitis, A. (2019). Enhancing reflection and empathy skills via using a virtual reality-based learning framework. *International Journal of Emerging Technologies in Learning (iJET)*, 14(7), 18–29. https://doi.org/10.3991/ijet.v14i07.9946

(Stanyon et al., 2022) Stanyon, R., Tomlinson, A., Kainth, M., & Wilkin, N. (2022). Providing individual student feedback at scale for mathematical disciplines. In *L@S 2022 – Proceedings of the 9th ACM Conference on Learning @ Scale* (pp. 400–404). ACM: New York. https://doi.org/10.1145/3491140.3528313

(Stephen & Kunnumpurath, 2024) Stephen, C., & Kunnumpurath, B. (2024). Virtual reality Tilt Brush for creativity: An experimental study among architecture students. *Nanotechnology Perceptions*, 20(S11), 690–706. *Available online*: https://nano-ntp.com/index.php/nano/article/view/2017/1572 (accessed on 13 June 2025).

(SRI International, 2022) SRI International. (2022). Moderate impact of adaptive systems: Effect size analysis. *Available online*: https://www.numberanalytics.com/blog/top-7-intelligent-adaptive-learning-systems-education-success (accessed on 23 May 2025).

(Suhag, 2024) Suhag, N. (2024). The impact of virtual reality on student engagement in higher education [Working paper]. *SSRN*, 10 November. *Available online*: https://ssrn.com/abstract=5016008 (accessed on 21 May 2025).

(Tomorrow Desk, n.d.) Tomorrow Desk. (n.d.). Learning management platform. *Available online*: https://tomorrowdesk.com/learning-management-platform/ (accessed on 4 July 2025).

(Tulasi & Rao, 2023) Tulasi, L., & Rao, C.S. (2023). Integration of AI-technologies into ELT: A brief study. *Journal for Research Scholars and Professionals of English Language Teaching*, 7(38). *Available online*: https://www.researchgate.net/publication/372638098_Integration_of_AI-Technologies_into_ELT_A_Brief_Study (accessed on 23 May 2025).

(Turnitin, 2024) Turnitin. (2024). Turnitin celebrates one year for AI writing detection. *Available online*: https://www.turnitin.com/blog/turnitin-celebrates-one-year-for-ai-writing-detection (accessed on 21 May 2025).

(Uptale, n.d.) Uptale. (n.d.). Immersive learning and Moodle: Now compatible! *Available online*: https://www.uptale.io/en/blog/immersive-learning-and-moodle-now-compatible/ (accessed on 4 July 2025).

(Van der Meer et al., 2023) Van der Meer, N., van der Werf, V., Brinkman, W.-P., & Specht, M. (2023). Virtual reality and collaborative learning: A systematic literature review. *Frontiers in Virtual Reality*, 4, 1159905. https://doi.org/10.3389/frvir.2023.1159905

(Vázquez & Palencia, 2024) Vázquez, B., & Palencia, J. (2024). A classroom experience for teaching and learning of high school geometry through virtual reality. *Pedagogical Research*, 9(3), em0210. https://doi.org/10.29333/pr/14634

 doi:10.20944/preprints202601.1173.v1

(VictoryXR, n.d.) VictoryXR. (n.d.). Learning in the Metaverse – Metaversity. *Available online*: https://www.victoryxr.com/metaversity/ (accessed on 22 May 2025).

(Weidener & Fischer, 2024) Weidener, L., & Fischer, M. (2024). Proposing a principle-based approach for teaching AI ethics in medical education. *JMIR Medical Education*, 10, e55368. https://doi.org/10.2196/55368

(Wiredu et al., 2024) Wiredu, J.K., Abuba, N.S., & Zakaria, H. (2024). Impact of generative AI in academic integrity and learning outcomes: A case study in the Upper East Region. *Asian Journal of Research in Computer Science*, 17(8), 70–88. https://doi.org/10.9734/ajrcos/2024/v17i7491

(Xu, 2022) Xu, Y. (2022). An adaptive learning system for English vocabulary using machine learning. *Mobile Information Systems*, 2022, 3501494. https://doi.org/10.1155/2022/3501494

(Yazdi et al., 2024) Yazdi, A., Mystakidis, S., & Karimi, B. (2024). Gamification in online education: Bibliometric review and emerging trends. *Information*, 15(2), 81. https://doi.org/10.3390/info15020081

(Zhou et al., 2024) Zhou, X., Zhang, J., & Chan, C. (2024). Unveiling students' experiences and perceptions of artificial intelligence usage in higher education. *Journal of University Teaching and Learning Practice*, 21(6). https://doi.org/10.53761/xzjprb23

(Zlatanović et al., 2020) Zlatanović, D., Nikolić, J., & Nedelko, Z. (2020). A systemic approach to improving innovativeness in higher education. *Teme*, XLIV(2), 441–460. https://doi.org/10.22190/TEME180703001Z