Pakistan Journal of Life and Social Sciences
www.pjlss.edu.pk

RESEARCH ARTICLE

Building a Future-Ready Educational Infrastructure: Localized Integration of Metaverse Technology in Saudi Arabia

Prof. Abdullah A. Al Fraidan

Department of English Language, College of Arts , King Faisal University, Al Ahsa, Saudi Arabia

ARTICLE INFO	ABSTRACT
  *Corresponding Author afridan@kfu.edu.sa	The strategic integration of metaverse technology into education represents a paradigm shift that holds significant potential, particularly within the context of Saudi Arabia's Vision 2030. This paper proposes a comprehensive framework designed to embed metaverse technologies into the Saudi educational system, emphasizing cultural relevancy, AI-driven personalized learning, and the creation of immersive experiences that enhance educational outcomes. Central to this framework is the development of culturally tailored content that reflects Saudi heritage, training programs for educators and content developers to maximize technological benefits, and policies that ensure data security and user safety. The Kingdom's sophisticated technological infrastructure and pioneering efforts in cybersecurity provide a solid foundation for the secure and effective implementation of metaverse technologies. These elements collectively contribute to a learning environment that is interactive, student-centered, and in harmony with local values and community expectations. The proposed model aims to elevate educational practices through sustained innovation, fostering an inclusive and future-ready system that aligns seamlessly with the ambitions of Vision 2030. The results promise not only a more engaging and culturally embedded educational experience but also a robust, scalable model that can be adapted across different educational landscapes.

INTRODUCTION

The global shift toward online education, significantly accelerated by the COVID-19 pandemic, underscored numerous limitations within existing digital learning frameworks. Traditional online education platforms, while effective in providing access to learning, often fall short in creating engaging and interactive experiences that captivate students. These frameworks commonly suffer from diminished student engagement, static content, and an inadequate level of personalization, leading to suboptimal learning outcomes and lower overall satisfaction among students and educators alike (Okyere et al., 2022; Suhairi et al., 2023). The lack of physical interaction and the impersonal nature of traditional online classes contribute to issues of isolation and disengagement, which further exacerbate educational challenges and widen achievement gaps (Hong et al., 2021; Wallace, 2003).

In this context, Saudi Arabia's Vision 2030 presents a strategic framework aimed at transforming the country's education system through the adoption of innovative technologies (Al Fraidan & Olaiwi, 2024). This vision seeks to establish an education sector that is not only more effective but also more inclusive, preparing students for future technological advancements and economic diversification. The integration of cutting-edge solutions, such as metaverse technologies, aligns perfectly with this ambition, offering a pathway to bridge current educational gaps and enhance

the learning environment (Buhalis et al., 2022; Park & Kim, 2022a; Al Fraidan, 2024c). The metaverse, defined as a multi-layered, immersive virtual space that merges physical and digital realities, presents a revolutionary approach to education by offering highly interactive, adaptive, and engaging experiences (Hadi et al., 2023; Singla et al., 2023).

The potential of the metaverse extends beyond traditional screen-based interactions. It leverages a combination of virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) to create a shared, immersive environment where students can engage in simulations, collaborate with peers, and receive real-time feedback (Al Fraidan & Olaiwi, 2024). This transformative technology fosters an active learning atmosphere that can replicate real-world experiences, making it particularly beneficial for subjects that rely on practical application, such as language acquisition, vocational training, and STEM education (Rahman et al., 2023; Onu et al., 2024). The immersive nature of metaverse technologies enables students to move from being passive recipients of information to active participants in their learning journey, thereby enhancing motivation, retention, and skill development (Patiar et al., 2021).

However, the path to implementing metaverse technologies is not without challenges (Al Fraidan & Olaiwi, 2024). High costs, digital literacy barriers, and concerns about data privacy present significant hurdles that must be addressed for successful adoption (Ajani, 2023; Akyürek et al., 2024). Despite these obstacles, the strategic adoption of metaverse solutions offers promising prospects for Saudi Arabia to modernize its educational landscape and align with Vision 2030's goals of cultivating a technologically advanced, knowledge-based society. By integrating immersive technologies, Saudi educators and policymakers can create a learning environment that is more adaptive, culturally relevant, and capable of meeting the diverse needs of students in the   digital   age. Practical mitigation strategies, such as leveraging public-private partnerships to offset costs, implementing digital literacy training programs for educators and students, and adopting robust data privacy protocols, are crucial for successful integration.

LITERATURE REVIEW

Metaverse in Education

The metaverse represents a transformative platform that seamlessly integrates virtual and augmented realities, fostering highly interactive and engaging learning experiences. Scholars have underscored the significant potential of these immersive environments to simulate real-world settings, making them particularly valuable for practical training and experiential learning across various disciplines (Buhalis et al., 2022). The use of metaverse technologies allows educators to create dynamic educational experiences where students can engage more fully with course content. For example, avatars can be employed for virtual field trips, enabling students to explore historical landmarks, natural ecosystems, or even complex scientific phenomena without leaving the classroom (Rahman et al., 2023). This virtual exploration offers a level of interaction and experiential learning that traditional classroom settings struggle to replicate.

One of the primary advantages of metaverse-based education is its suitability for fields that require practical application and experiential learning. Language acquisition is a notable example; within a metaverse environment, students can practice speaking and listening skills in context-specific scenarios, such as conversing in a simulated marketplace or participating in a guided cultural exchange (Patiar et al., 2021). Similarly, vocational training benefits greatly from the metaverse's capacity to mimic workplace environments, providing students with hands-on practice in tasks such as machinery operation, hospitality management, or medical procedures (Onu et al., 2024). These practical simulations not only help students develop technical skills but also reinforce their problem-solving and critical-thinking abilities in a risk-free setting.

Moreover, metaverse technologies align with constructivist learning theories, which advocate for active, learner-centered education. In a metaverse setting, students can collaborate with peers in real-time, engaging in problem-based learning and projects that mirror real-world challenges

(Singla et al., 2023). The incorporation of elements like gamification and interactive simulations can further enhance student motivation, fostering a sense of achievement and sustained interest in their studies (Park & Kim, 2022a). The immersive nature of the metaverse encourages students to take ownership of their learning, as they can explore content at their own pace and revisit complex concepts through repeated interactions.

Despite its transformative potential, the implementation of metaverse technology in education faces significant challenges. One major concern is the high cost associated with the infrastructure needed to support VR/AR tools and high-speed internet connectivity (Akyürek et al., 2024). For many educational institutions, particularly those in developing regions, the financial burden can be a deterrent to adopting such advanced technologies. Additionally, digital literacy remains a critical issue. Both educators and students need training to effectively utilize metaverse platforms, which requires dedicated time and resources (Kluge et al., 2022). Without adequate training, the potential benefits of the metaverse could be undermined by improper use or a lack of understanding (Greenleaf, 2019; Meccawy, 2023).

Privacy and data security also present significant challenges. The metaverse collects and processes substantial amounts of user data to deliver personalized and immersive experiences. This raises concerns about data privacy, user safety, and compliance with regulations (Greenleaf, 2019; Ajani, 2023; Zhou & Kim, 2022). Addressing these challenges requires the development of comprehensive policies that ensure data protection, promote responsible use, and safeguard users' rights. Institutions must establish clear guidelines and real-time monitoring mechanisms to protect against data breaches and unauthorized use (Zhang et al., 2022). Saudi Arabia's cybersecurity policies align with international standards such as the GDPR, emphasizing data minimization, transparency, and user rights. The Kingdom's National Cybersecurity Authority (NCA) enforces stringent regulations, providing a robust framework to protect student data in metaverse environments.

To achieve the potential benefits of metaverse integration while overcoming these obstacles, a strategic and multifaceted approach is necessary. Policymakers and educational leaders must prioritize investments in infrastructure and training programs that build digital proficiency among educators and students. Furthermore, incorporating culturally relevant content and aligning metaverse-based learning modules with local educational standards are essential for fostering a meaningful and inclusive learning experience (Greenleaf, 2019; Meccawy, 2023).

Overall, the literature highlights that while the metaverse holds great promise for revolutionizing education by enhancing engagement, interaction, and practical learning, these benefits can only be realized through well-considered strategies that address the associated challenges.

Challenges in Current Online Education

Traditional online education platforms, while providing accessibility and convenience, often fall short in terms of interactivity and personal connection, which are crucial for maintaining student motivation and engagement (Wallace, 2003). The shift to online learning, hastened by the COVID-19 pandemic, brought these challenges into sharper focus. Students frequently report feeling isolated and disconnected when participating in fully online learning environments. The absence of face-to-face interactions, which naturally foster a sense of community and camaraderie, can lead to a diminished sense of belonging and lower participation rates (Hong et al., 2021). This disconnect contributes to disengagement and reduced academic performance, as students may struggle to stay motivated and feel invested in their learning experiences.

The problem is exacerbated in subjects that benefit from hands-on learning and real-time feedback, such as STEM fields, language acquisition, and vocational training. These disciplines rely on interactive methods that involve practical exercises, group discussions, and in-person activities to build competence and confidence (Hafeez et al., 2022). Without these components, students may find it challenging to develop the practical skills needed for success. In fields like science and engineering, where lab work and physical manipulation of materials are critical, the

limitations of traditional online education can significantly hinder learning outcomes. Similarly, language learning loses its effectiveness when students are unable to engage in conversational practice and immediate feedback, which are essential for fluency development.

Online education platforms often rely heavily on passive learning methods, such as pre-recorded lectures and static readings, which may not fully engage students or cater to different learning styles. The lack of dynamic and interactive content can make learning monotonous, leading to a decline in student participation and knowledge retention. Furthermore, technical issues such as unreliable internet connections and outdated software can further disrupt the learning process and contribute to student frustration.

The metaverse presents a potential solution to these challenges by offering a platform where students can engage in highly interactive and immersive learning environments. Unlike traditional online education, the metaverse allows learners to actively participate in simulations, role-plays, and collaborative projects that mirror real-world scenarios. These interactive features give students a more active role in their education, which has been shown to increase motivation and improve retention of information (Park & Kim, 2022a). For instance, students studying architecture or engineering can design and test models in a virtual space that mimics real-world conditions, receiving immediate feedback and making real-time adjustments. Similarly, medical students can practice complex procedures in a safe and controlled virtual environment before applying their skills in real-world settings (Kluge et al., 2022).

Collaborative projects within the metaverse also foster a sense of community and teamwork, addressing one of the most significant drawbacks of traditional online learning—the lack of social interaction. In a metaverse classroom, students can form study groups, participate in discussions, and collaborate on projects with peers, even if they are physically located in different parts of the world. This collaborative aspect not only enhances engagement but also helps students develop critical soft skills such as communication, problem-solving, and teamwork, which are essential for success in both academic and professional settings.

Additionally, metaverse-based education can be tailored to provide individualized learning paths, catering to diverse learning preferences and abilities. Through the integration of artificial intelligence, students can receive personalized content and adaptive learning experiences that respond to their progress and feedback, further enhancing motivation and learning outcomes (Rahman et al., 2023). This personalization ensures that students who may otherwise fall behind in traditional online settings receive the support and tailored instruction they need to succeed.

Despite the potential benefits, adopting metaverse technologies to address the challenges of traditional online education requires careful consideration of associated obstacles, such as accessibility, cost, and digital literacy. However, when effectively implemented, the metaverse holds the promise of transforming online education into a more interactive, engaging, and effective experience that better meets the needs of modern learners.

The Proposed Model for Saudi Education

The proposed model for metaverse integration in Saudi Arabia's educational framework aims to align with Vision 2030 by enhancing the quality, inclusivity, and technological sophistication of education. This comprehensive model includes essential components to ensure effective implementation and widespread acceptance.

1- Technology Infrastructure

Implementing metaverse technologies in education necessitates a robust and scalable infrastructure capable of supporting high-performance computing, stable, high-speed internet connectivity, and advanced hardware such as VR/AR headsets (Coyne et al., 2021). Saudi Arabia has made significant strides in developing a state-of-the-art technological infrastructure, laying a strong foundation for the adoption of immersive learning technologies. The country's advanced digital infrastructure is a result of strategic investments and forward-thinking initiatives aimed at positioning Saudi Arabia as a leader in technology and innovation.
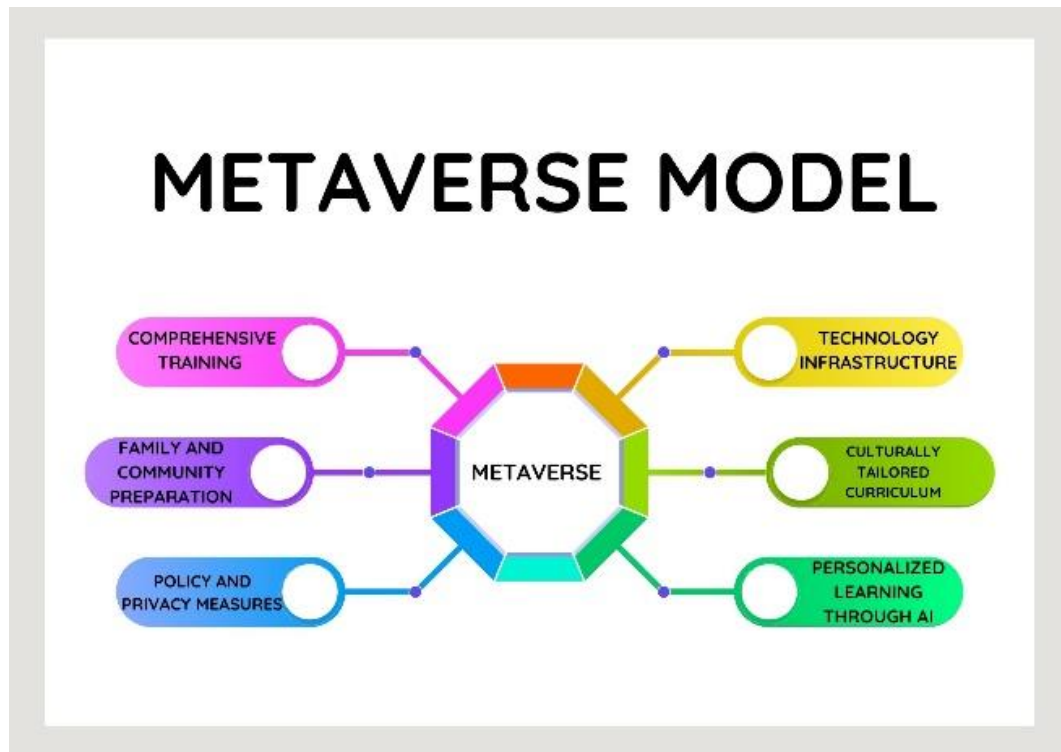
Figure1: the proposed model for Metaverse implementation in Saudi Arabia

Current State of Infrastructure

Saudi Arabia's infrastructure is among the most developed in the region, marked by extensive high-speed internet coverage, modern data centers, and sophisticated cloud services. The implementation of Vision 2030 has further accelerated the nation's focus on digital transformation, leading to substantial investments in telecommunications and information technology. The Kingdom's advanced 5G networks, deployed across urban and rural areas, provide the high-speed, low-latency connectivity required for metaverse applications to function smoothly. This connectivity ensures that metaverse-driven educational tools can operate efficiently, supporting real-time interactions, high-definition visuals, and seamless VR/AR experiences.

Efforts to Improve Infrastructure

To bolster its digital capabilities, the Saudi government has partnered with private sector entities to expand and enhance technological infrastructure. This includes collaborations with leading tech giants like IBM, Microsoft, and Huawei to establish cutting-edge data centers and develop cloud computing solutions that can support large-scale virtual applications. The Ministry of Communications and Information Technology (MCIT) has spearheaded multiple initiatives to foster innovation and improve internet accessibility, such as the National Transformation Program (NTP), which prioritizes the development of digital infrastructure to meet the demands of an increasingly connected society.

Additionally, the Saudi Data and Artificial Intelligence Authority (SDAIA) has been pivotal in promoting AI integration and ensuring that the infrastructure supports future technological advancements. The authority has launched strategic programs like the National Strategy for Data and Artificial Intelligence (NSDAI), which aims to transform the country into a global leader in AI by enhancing data analytics, machine learning capabilities, and cloud computing infrastructure.

Conferences and Technological Initiatives

Saudi Arabia has demonstrated its commitment to technological leadership through numerous conferences and events that focus on innovation, AI, and digital transformation. One notable

example is the Global AI Summit, hosted by the SDAIA, which brings together global experts, policymakers, and industry leaders to discuss advancements in AI and its applications across sectors, including education. The summit serves as a platform for knowledge sharing, networking, and the exploration of how AI can be integrated into various domains to drive progress.

Another significant event is the LEAP technology conference, which showcases the latest in tech innovation and draws participation from tech visionaries, entrepreneurs, and educators. LEAP has become a cornerstone for highlighting cutting-edge technologies such as metaverse applications and VR/AR solutions, emphasizing their potential in transforming educational practices. These conferences not only foster innovation but also inspire collaborations between educational institutions and technology developers to create infrastructure capable of supporting immersive educational tools.

Hackathons and Innovation Challenges

The Kingdom has also hosted numerous hackathons and innovation challenges aimed at fostering creativity and developing practical solutions to current technological challenges. Events such as the Hajj Hackathon, which attracted participants from around the world, focus on leveraging technology to solve real-world problems. While primarily centered on optimizing logistical challenges, such events showcase Saudi Arabia's commitment to fostering a culture of innovation that can extend to educational advancements. Similarly, the AI Artathon, organized by SDAIA, brought together artists and AI specialists to create AI-driven artwork, demonstrating the integration of technology and creativity, an approach that can be mirrored in educational content development.

The Role of Collaborative Partnerships

To sustain and enhance its infrastructure, Saudi Arabia has formed strategic partnerships between educational institutions, government bodies, and private tech companies. These collaborations facilitate the exchange of expertise, funding, and technological resources necessary for the development and maintenance of a metaverse-friendly infrastructure. Such partnerships are instrumental in ensuring that all students, regardless of their socioeconomic background, have access to high-quality learning experiences supported by the latest technology (Akyürek et al., 2024; Al-Adwan et al., 2023).

Saudi Arabia's advanced infrastructure, combined with continuous improvements driven by government initiatives and strategic partnerships, positions the country well for the integration of metaverse technologies into its educational system. The comprehensive 5G network, the establishment of data centers, and a strong emphasis on AI and cloud computing provide a robust platform for metaverse applications. The Kingdom's dedication to hosting conferences, hackathons, and innovation challenges underscores its commitment to staying at the forefront of technological progress, ensuring that its educational landscape is prepared for the next era of digital learning.

2- Culturally Tailored Curriculum

One of Vision 2030's core objectives is to preserve and promote Saudi culture and heritage while advancing the nation's technological landscape. This dual focus not only modernizes the educational system but also reinforces the importance of cultural identity in an increasingly globalized world. Integrating culturally tailored content into metaverse learning modules is essential for creating an educational experience that resonates with students and facilitates active participation. By embedding cultural elements into immersive learning experiences, educators can enhance student engagement and foster a deeper connection to the content being taught (Meccawy, 2023; Patiar et al., 2021).

The Ministry of Culture in Saudi Arabia has been pivotal in promoting and preserving the Kingdom's rich heritage through various initiatives. These efforts include organizing cultural festivals, supporting traditional art forms, and investing in the digital documentation of heritage

sites. Initiatives such as the "Year of Arabic Calligraphy" and various regional art and music festivals have been instrumental in reviving and celebrating the cultural practices of Saudi Arabia. The ministry's focus on digital transformation and cultural promotion aligns seamlessly with the use of metaverse technologies, providing new avenues for sharing Saudi culture with the world.

The metaverse can play a significant role in amplifying the Ministry of Culture's mission by creating virtual cultural experiences that are accessible globally. Through metaverse platforms, students and audiences around the world can participate in immersive tours of Saudi heritage sites, interact with 3D models of traditional crafts, and engage in digital performances of folk music and dance. This technological integration ensures that Saudi culture is not only preserved but also shared widely, fostering greater cultural appreciation and understanding on an international scale.

Virtual Tours and Cultural Immersion:

The metaverse offers unparalleled opportunities to create educational modules that feature virtual tours of significant historical and cultural sites. Students can explore locations such as the historic Diriyah, the ancient Nabatean city of AlUla, and the bustling souks of Jeddah through immersive virtual experiences. These virtual tours provide a level of detail and interactivity that traditional classroom learning cannot match, allowing students to visualize and understand the historical and cultural significance of these sites firsthand. This kind of learning deepens students' appreciation of their heritage and strengthens their cultural identity, making lessons more impactful and engaging.

Interactive Lessons on Traditional Arts and Practices

Incorporating lessons on traditional arts and practices into metaverse platforms can enrich the curriculum and offer students hands-on experiences. Interactive modules could include activities such as learning the traditional Saudi dance of Al-Ardha or understanding the intricate designs of Islamic calligraphy and Najdi art. By engaging in these virtual recreations, students can gain practical knowledge of their cultural heritage while simultaneously developing digital skills. This approach ensures that cultural education remains dynamic, integrating traditional practices with modern technological tools.

Culturally Rich Language Learning and Social Studies

The metaverse can also be a powerful tool for teaching language and social studies in culturally immersive ways. For instance, language learning modules can be designed to simulate real-life conversations in culturally significant settings, such as navigating a traditional market or attending a community festival. These scenarios help students practice their language skills within relevant cultural contexts, making learning both practical and enjoyable (Patiar et al., 2021). Social studies lessons can include role-playing activities where students engage in historical reenactments or explore societal changes through different eras, fostering critical thinking and empathy.

Familiarizing Students with Advanced Technologies

Integrating culturally tailored curriculum within the metaverse helps familiarize students with emerging technologies in a context that feels familiar and engaging. When students encounter technology through content that reflects their cultural background, it becomes less intimidating and more accessible. This gradual exposure helps build their digital literacy and confidence, preparing them for more complex technological interactions in the future. The comfort and familiarity students gain through culturally resonant content can expedite their acceptance and enthusiasm for the metaverse and similar advanced technologies.

By grounding metaverse experiences in familiar cultural themes, educators can address potential resistance to new technology. Families and communities that may be wary of adopting new educational tools are more likely to support these initiatives when they see them being used to promote and preserve cultural heritage. This alignment with cultural values reinforces the idea

that technology is a means to enrich, not replace, traditional learning. As students and their families see firsthand how these technologies can bridge the past and the present, the path to wider acceptance and integration of metaverse tools into everyday learning becomes clearer.

Blending Traditional and Modern Practices

The metaverse's capacity to blend traditional learning methods with modern practices provides a comprehensive educational approach that aligns with Vision 2030's goals. For instance, while students might study Saudi poetry or literature through traditional means, metaverse modules can enhance this learning by allowing students to virtually interact with historic poets in recreated cultural settings or participate in storytelling sessions. Such innovative blends of old and new practices help students apply their cultural knowledge in a modern context, preparing them to engage in global conversations without losing their cultural roots.

Benefits for Community and Family Engagement

A culturally tailored curriculum in the metaverse also encourages greater community and family involvement. Parents and guardians can be invited to participate in virtual sessions that showcase cultural heritage, bridging generational gaps and fostering shared experiences. This communal approach helps families see the value of technology as an extension of their cultural learning, creating an ecosystem of support that nurtures both educational and cultural growth.

A culturally tailored curriculum integrated into metaverse platforms offers a transformative opportunity for Saudi education. By blending cultural heritage with modern technology, students are not only engaged but also empowered to become active participants in their learning. This strategy strengthens cultural identity, promotes digital literacy, and facilitates the acceptance of new technologies among students, their families, and the broader community, aligning perfectly with the ambitious goals of Vision 2030. The Ministry of Culture's efforts to preserve and promote heritage can be significantly bolstered by metaverse technologies, enabling the global sharing of Saudi culture in innovative and impactful ways.

3-   Personalized Learning Through AI

Artificial intelligence (AI) stands as a transformative force in enhancing metaverse-based education by creating personalized learning paths tailored to individual student needs. AI-driven educational platforms can leverage machine learning algorithms to analyze student interactions, monitor progress, and adapt content dynamically (Al Fraidan, 2024a; Al Fraidan 2024b). This real-time feedback and personalized content adjustment ensure that each learner receives a unique and supportive educational experience that aligns with their pace, learning style, and performance (Rahman et al., 2023; Kluge et al., 2022). This approach not only supports advanced learners in exploring more challenging material but also provides targeted assistance to those who may struggle, effectively fostering an inclusive learning environment.

AI's Role in Engagement and Differentiation

One of the greatest strengths of AI in the metaverse lies in its ability to maintain student engagement. Traditional educational models often struggle to address the varying paces and learning preferences within a single classroom. AI bridges this gap by offering differentiated instruction—adapting learning materials and methods to suit each student's unique needs. For example, visual learners might receive interactive 3D models and simulations, while auditory learners might benefit from narrated guides or real-time verbal feedback. This adaptability ensures that students stay engaged, reducing dropout rates and fostering a deeper connection with their learning material.

I believe that AI's integration into education represents one of the most significant advancements of our time. In the context of personalized learning, AI can revolutionize how educators approach teaching by allowing for more granular insights into student progress and behavior. Data collected through AI-powered platforms can help teachers identify learning gaps, predict which students might need intervention, and create a more holistic approach to academic support. This

shift empowers educators to move beyond a one-size-fits-all methodology and implement strategies that maximize individual student potential.

However, it is crucial to recognize that the application of AI in education should be balanced with a human-centric approach. While AI can provide the analytics and adaptive technology needed to personalize learning, the role of educators remains essential. Teachers provide the empathy, motivation, and real-world insights that technology cannot replicate. AI should serve as a powerful tool that complements educators' expertise, enabling them to focus more on mentorship and less on administrative tasks.

Real-Time Feedback and Adaptive Learning

The real-time feedback capabilities of AI enhance the metaverse learning environment by keeping students informed about their progress. Immediate feedback not only reinforces correct answers and identifies mistakes but also promotes self-reflection and active learning. This feature encourages students to take an active role in their education, fostering independence and critical thinking skills. Adaptive learning systems, powered by AI, can modify the difficulty level of tasks based on student responses, ensuring that students are neither overwhelmed nor under-challenged. This helps maintain an optimal zone of learning where students are motivated to progress without feeling frustrated or bored.

Insights for Educators

AI-driven data collection provides invaluable insights for educators to refine their teaching strategies. By analyzing how students interact with different types of content, educators can better understand which teaching methods are most effective and which areas require improvement. For instance, if data shows that students perform better with interactive simulations over traditional reading assignments, teachers can adjust their lesson plans to incorporate more immersive content. This data-driven approach enhances the effectiveness of instruction and contributes to improved learning outcomes at both individual and class-wide levels.

While the potential of AI in metaverse-based education is immense, it is not without challenges. Ensuring data privacy and ethical use of student information is paramount. Institutions must establish strict policies to protect student data and maintain transparency about how AI-driven insights are used. Additionally, educators and students need to build a level of digital literacy to understand and trust the AI-driven tools they are using. Training programs and ongoing support can help both teachers and students become comfortable and proficient in leveraging AI for educational benefits.

The use of AI in personalized learning within metaverse environments offers unprecedented opportunities to engage students, provide tailored instruction, and improve educational outcomes. With AI's real-time feedback, adaptive learning capabilities, and rich data analytics, educators are better equipped to meet the diverse needs of their students and foster an environment of continuous improvement. However, the role of human oversight remains vital. Integrating AI in education should enhance, not replace, the personal touch that teachers bring to the learning experience. With thoughtful implementation, AI can serve as a powerful partner in achieving the educational goals outlined in Saudi Vision 2030, driving progress and inclusivity in the nation's learning landscape.

4-   **Comprehensive Training for Instructors and Students**

For the effective implementation of metaverse technologies in education, comprehensive training programs must be developed for both educators and students. These programs should aim to equip instructors with the technical skills and pedagogical strategies necessary to integrate and manage metaverse platforms effectively (Kluge et al., 2022). This includes practical training on the use of VR/AR tools, the creation of immersive and interactive content, and techniques for fostering dynamic virtual classrooms that promote active learning and participation. For

students, training should provide clear guidance on navigating and utilizing metaverse resources efficiently, ensuring they can maximize the potential of these tools for their academic success.

The Importance of Training Programs

Training programs are essential because the shift to a metaverse-based educational system demands a different skill set than traditional teaching or conventional online learning. Educators need to understand not just the technical aspects of these tools but also how to integrate them into their teaching practices in a way that enhances learning outcomes. Workshops and ongoing professional development initiatives are vital to maintaining high levels of competence and adaptability as educational technologies continue to evolve (Al-Adwan et al., 2023; Md Nor & Mahzan, 2023). This continuous support helps educators stay updated on new features, best practices, and innovative teaching methods that leverage the power of the metaverse.

Addressing the Knowledge Gap

From my perspective, one of the most significant barriers to successfully implementing new educational technologies, including the metaverse, is the lack of adequate training and knowledge among educators. While metaverse technology holds immense potential to transform learning, most challenges stem from gaps in understanding how to use these tools effectively. Educators may feel overwhelmed or resistant to change due to insufficient familiarity with new platforms and teaching methods. This lack of training can lead to underutilization of technology and missed opportunities to create enriched learning experiences.

To address this issue, training programs must go beyond a single session or short-term workshops. Instead, they should be continuous and comprehensive, providing educators with hands-on experience, mentorship, and access to expert support. Training should be structured to build confidence, starting with basic introductions and progressing to more complex applications, such as creating custom VR lessons or interactive simulations.

A significant challenge in providing this training is ensuring it is accessible to all educators, regardless of their technological background. Not all teachers may be familiar with immersive technologies or possess the digital literacy needed to fully engage with these tools. This disparity can result in an uneven adoption of metaverse-based teaching across educational institutions.

To bridge this gap, training programs should be differentiated based on the participants' current level of technical expertise. Introductory courses can help teachers build foundational skills, while advanced workshops can focus on developing innovative teaching strategies and integrating complex tools. Moreover, incorporating collaborative learning opportunities where educators can share experiences, challenges, and solutions can help build a supportive community that encourages continuous learning and improvement.

Training for Students

Students also need structured training to help them effectively use metaverse tools. While younger generations may be more accustomed to technology, the metaverse introduces new layers of interaction and complexity. Training should help students understand how to engage with virtual lessons, navigate 3D spaces, and use interactive content responsibly and effectively. Workshops, tutorials, and guided sessions should be part of the curriculum to ensure students are comfortable and confident in using these platforms.

Both students and educators must be equipped not only with technical skills but also with the ability to adapt as technology evolves. A culture of digital proficiency and a mindset geared towards continuous learning must be fostered. Educational institutions can encourage this by integrating regular updates, feedback loops, and training refreshers to keep knowledge up-to-date.

Comprehensive training programs are the backbone of any successful technology integration in education. Addressing the knowledge gap among educators and providing ongoing support can

overcome resistance to change and enhance the effective use of metaverse technologies. By prioritizing long-term, differentiated training programs for both instructors and students, educational institutions can ensure that technology is fully leveraged to enrich learning and align with educational goals, such as those outlined in Saudi Vision 2030. This approach not only improves the use of metaverse tools but also empowers educators and students to be confident and capable digital learners and leaders.

Training for Content Developers

Training for content developers is a critical element in the successful implementation of metaverse technologies in education. Content developers are responsible for creating the immersive, interactive, and culturally relevant educational materials that populate metaverse platforms. Their work ensures that the digital learning environment is not only engaging but also aligns with curricular goals and local cultural values. Comprehensive training programs for content developers must focus on the technical and creative aspects of developing high-quality metaverse content, including 3D modeling, interactive storytelling, user experience (UX) design, and programming specific to VR/AR environments (Kluge et al., 2022; Rahman et al., 2023).

The Importance of Training Content Developers

Training content developers equips them with the necessary skills to build educational modules that meet the unique needs of Saudi learners. This training should cover best practices in content creation, design principles for immersive learning, and the integration of AI to create adaptive and interactive lessons. Such programs ensure that developers can produce content that aligns with educational standards and leverages the full potential of metaverse technologies (Patiar et al., 2021; Meccawy, 2023).

From my perspective, one of the most pressing challenges in the effective adoption of metaverse technology in Saudi education is the shortage of skilled content developers. The development of high-quality, localized content is essential to making metaverse learning both relevant and impactful for students. Without a strong base of trained developers, educational institutions may find themselves relying on generic, non-localized content that lacks cultural context and relevance. This dependence on external sources can limit the effectiveness of metaverse integration and hinder the personalization of educational experiences that resonate with Saudi students (Akyürek et al., 2024).

Localization and Local Content Production

Training content developers is not only vital for the quality and customization of metaverse content but also for the localization and sustainability of this technology. Local developers bring an understanding of cultural nuances, language, and educational practices that are crucial for creating content that aligns with local educational standards and cultural expectations (Meccawy, 2023). This ensures that students are learning in an environment that feels familiar and relevant, which enhances engagement and comprehension.

Investing in training programs that build local expertise supports the production of tailored educational materials that reflect Saudi Arabia's rich heritage and contemporary educational needs. This localization helps integrate traditional elements, such as historical narratives, local traditions, and culturally significant practices, into immersive learning experiences (Patiar et al., 2021). It makes learning more relatable and can inspire students to connect with their roots while engaging with cutting-edge technology.

Sustainability of Metaverse Technology

Developing a pool of skilled, locally trained content creators is essential for the long-term sustainability of metaverse technology in education. When content production is localized, educational institutions can more readily update and expand their learning materials to adapt to new curricular goals and technological advancements. This approach reduces dependency on

foreign content and services, promoting self-sufficiency and economic sustainability (Al-Adwan et al., 2023). Additionally, fostering local talent encourages innovation within the country and supports the development of homegrown tech industries aligned with the objectives of Vision 2030 (Akyürek et al., 2024; Ajani, 2023).

Training content developers is an investment that pays dividends by fostering a sustainable ecosystem for educational technology. From my standpoint, the absence of sufficient training programs has limited the rapid development of metaverse applications, and addressing this gap is crucial. Empowering local talent to develop metaverse content ensures that the technology remains adaptable and responsive to the needs of Saudi educational institutions. It also aligns with Vision 2030's aim to create a self-sustaining, innovation-driven economy (Akyürek et al., 2024; Al-Adwan et al., 2023).

The training of content developers is indispensable for the successful integration and sustainability of metaverse technology in education. By investing in robust training programs that focus on both technical and cultural competencies, Saudi Arabia can cultivate a generation of developers capable of producing localized, high-quality content. This approach supports the sustainability of metaverse initiatives, fosters educational self-reliance, and ensures that students are engaged in culturally relevant learning experiences (Meccawy, 2023; Ajani, 2023). Such strategic investment will strengthen the role of metaverse technology in education and secure its place as a transformative tool in the Kingdom's educational landscape.

5-   Family and Community Preparation

The successful adoption of metaverse technology in education hinges not only on the readiness of schools and educators but also on the acceptance and support of families and the broader community. For students to thrive in a metaverse-based learning environment, it is essential that parents and guardians are informed and involved. Community engagement initiatives, such as workshops, open houses, and informational sessions, should be launched to raise awareness about the benefits and potential challenges of metaverse-based learning. These initiatives provide opportunities for families to understand how these technologies function and how they can support their children's learning at home (Ajani, 2023; Zhou & Kim, 2022). This involvement builds trust in new educational methods, fostering a supportive network that enhances student outcomes.

In my perspective, education begins at home, and parents play a pivotal role as partners in the educational journey. Their influence extends beyond the home, significantly impacting how students engage with school and new technologies. Parents who are knowledgeable about the benefits and uses of metaverse technologies can reinforce the learning experience by encouraging exploration, practice, and curiosity outside the classroom. When parents are well-informed, they can act as advocates for their children, providing guidance and creating an environment conducive to learning.

Parental involvement complements the efforts of schools and strengthens the educational process. A collaborative approach between home and school ensures that learning is consistent and holistic, incorporating values, cultural elements, and personal support that only families can provide. Schools that actively engage parents and the community in understanding the potential of metaverse-based education are more likely to see successful integration and greater student achievement.

Community Acceptance as a Key Factor

Community acceptance is by far one of the most crucial issues in the successful implementation of metaverse technology in education. Without the endorsement and understanding of the broader community, the adoption of new technologies can face significant resistance. Communities must be reassured that these advancements align with local values and educational priorities. To facilitate this acceptance, partnerships with community leaders and influencers can help convey the message that metaverse technologies are not replacing traditional values but

enhancing and modernizing them. These leaders can serve as cultural ambassadors, helping to shape metaverse content that reflects local traditions and values, making the technology more relatable and acceptable.

Workshops and Informational Sessions

Workshops and informational sessions tailored for parents and community members play a pivotal role in fostering understanding and acceptance. These sessions should be interactive, allowing attendees to experience metaverse platforms firsthand. Demonstrations can showcase how immersive learning can enhance subjects like history, language arts, and science, illustrating the practical benefits for students. Parents should leave these sessions with a clear understanding of how they can engage with and support their children's learning at home, whether through supplementary activities or by reinforcing what is learned in the classroom (Ajani, 2023).

Addressing Concerns and Building Trust

Many parents and community members may have concerns about the impact of metaverse technologies on students, including issues related to screen time, data privacy, and the potential for distraction. Schools should proactively address these concerns by highlighting the safeguards in place and explaining how responsible use is encouraged. Clear policies on privacy and data protection, as well as guidance on balanced screen time, can help reassure families that student well-being is a priority (Zhou & Kim, 2022). Transparent communication fosters trust and positions schools as partners in the shared goal of advancing education.

Encouraging Active Family Participation

Schools can go beyond basic workshops by involving parents in the development of metaverse content. Feedback from families can inform the creation of lessons that are not only academically rigorous but also culturally relevant and aligned with community values. When families see their input reflected in the educational content, they are more likely to feel invested and supportive of the technology.

The Role of the Community in Sustaining Innovation

A community that understands and supports metaverse technology can become a driving force for sustainable educational innovation. Community acceptance encourages local businesses, cultural organizations, and tech developers to collaborate with schools, contributing resources, expertise, and localized content. These partnerships enrich the learning ecosystem, making it more diverse and adaptable to the unique needs of the community. The shared responsibility between families, schools, and the community ensures that the adoption of metaverse technologies is not just a top-down initiative but a collaborative effort that reflects the aspirations of all stakeholders.

Family and community preparation are critical components for the successful integration of metaverse technology in education. Education starts at home, where parents play an essential role in supporting and complementing the efforts of schools. Community acceptance is equally important and can be nurtured through open dialogue, active participation, and partnerships that reflect local values. When parents and the community are engaged and informed, the transition to metaverse-based learning becomes smoother, more effective, and sustainable. This collective approach ensures that students receive the full benefits of innovative technology while maintaining cultural continuity and support.

6-   Policy and Privacy Measures

Developing robust policies and guidelines for the ethical use of metaverse technologies is essential to protect student data and maintain a safe learning environment. These policies should comprehensively address data privacy concerns, implement user safety protocols, and provide real-time monitoring and moderation to mitigate potential risks (Zhang et al., 2022). Establishing clear regulations ensures compliance with both local and international data protection standards,

safeguarding student information and promoting trust in new educational technologies. Ethical considerations related to user interactions, data collection, and content creation must also be integral to policy discussions, building a robust framework that supports the safe and responsible use of metaverse tools in education (Ajani, 2023; Zhou & Kim, 2022).

Saudi Arabia's Advanced Security Infrastructure and Cybersecurity Efforts

From my perspective, robust policy and privacy measures are not just beneficial but essential for the effective and sustainable use of educational technology. Saudi Arabia is well-positioned to lead in this area, boasting one of the most advanced security systems globally. The Kingdom's significant investments in cybersecurity reflect its commitment to protecting digital environments and user data, a priority that aligns with Vision 2030's push towards a technologically empowered society.

Saudi Arabia has taken substantial steps to enhance its cybersecurity framework through initiatives led by the National Cybersecurity Authority (NCA). The NCA has introduced comprehensive cybersecurity strategies and regulations that aim to protect public and private sector entities from cyber threats, ensuring the safety and integrity of digital infrastructure. This proactive approach includes partnerships with global cybersecurity firms, participation in international cybersecurity conferences, and the development of local expertise through training programs and certifications.

These efforts have strengthened the Kingdom's position as a leader in digital security, making it well-equipped to extend these capabilities to educational technologies, including metaverse platforms. By integrating advanced cybersecurity measures, Saudi Arabia can safeguard students' data, ensure the security of educational content, and maintain the trust of students, parents, and educators. This focus on security helps mitigate potential threats such as data breaches, unauthorized data collection, and malicious activities within virtual environments.

I firmly believe that the effectiveness of metaverse technology in education hinges on the strength of the policies and privacy measures in place. Without robust frameworks, the adoption of such advanced tools can lead to vulnerabilities that may compromise student data and trust. Comprehensive security policies must be paired with consistent updates and real-time monitoring to adapt to emerging threats in an ever-evolving digital landscape. Education technology should not only focus on innovation but also prioritize the safety and ethical handling of user data.

Essential Components of Effective Policies

Data Protection Regulations: Policies should define how student data is collected, stored, and used. These regulations must align with international standards such as the General Data Protection Regulation (GDPR) while adapting to local legal frameworks.

User Safety Protocols: Policies must include protocols that ensure user safety within virtual environments. This includes age-appropriate content guidelines, tools to report inappropriate behavior, and mechanisms for moderation.

Ethical Considerations: Comprehensive policy development should also address the ethical use of data and user interactions. This involves transparency about data usage, the ethical implications of data collection, and safeguards to prevent misuse.

Training and Awareness Programs: Ensuring that educators, students, and developers are trained on the policies and privacy measures is crucial. Awareness programs should be conducted to inform stakeholders about their rights and responsibilities regarding data security and ethical practices.

Strong policies and privacy measures not only protect data but also build trust among students, parents, and the broader community. For the successful adoption of metaverse technologies, it is

vital that families and communities feel confident that student data is secure and that educational environments are safe. Saudi Arabia's advanced cybersecurity measures can reassure parents and guardians, showcasing that the educational system prioritizes student safety and privacy.

The integration of rigorous policy and privacy measures supports Saudi Arabia's Vision 2030, which seeks to create an innovative, culturally inclusive, and technologically advanced education system. By leveraging its robust cybersecurity infrastructure, Saudi Arabia can lead the way in setting new standards for the secure implementation of metaverse technologies in education. This approach not only maximizes the educational benefits of the metaverse but also addresses challenges related to trust, data security, and ethical usage through proactive and strategic policymaking.

The development of robust policies and privacy measures is crucial for the effective, secure, and sustainable implementation of metaverse technologies in education. With its advanced cybersecurity systems and strategic efforts in protecting digital environments, Saudi Arabia is well-positioned to set an example in securing metaverse applications. These efforts ensure that student data is protected, learning environments are safe, and community trust is maintained. By prioritizing comprehensive policy development and continuous security advancements, Saudi Arabia can fully realize the potential of metaverse technology in education, aligning with the ambitious goals of Vision 2030 and fostering a forward-thinking, secure learning landscape.

DISCUSSION

The integration of metaverse technologies into Saudi Arabia's educational system marks a transformative step towards modernizing learning in alignment with Vision 2030. The findings of this systematic review reveal a complex interplay of opportunities and challenges, underscoring the need for strategic implementation grounded in empirical evidence and informed by theoretical frameworks.

As highlighted by Patiar et al. (2021) and Singla et al. (2023), metaverse technologies create immersive environments that promote active and experiential learning. These findings resonate with constructivist theories, which advocate for learner-centered education through collaboration and problem-solving. In the Saudi context, where traditional pedagogies often dominate, the metaverse offers an innovative alternative to engage students through simulations, gamification, and real-time feedback. For instance, virtual scenarios for language acquisition, such as marketplaces or cultural exchanges, provide contextualized learning experiences that traditional methods lack (Rahman et al., 2023).

Addressing Cultural and Societal Alignment

The integration of culturally relevant content within metaverse platforms, as discussed by Meccawy (2023) and Patiar et al. (2021), is pivotal in ensuring community acceptance and alignment with Saudi values. By embedding Saudi heritage into virtual learning modules—such as virtual tours of AlUla or lessons on Arabic calligraphy—the metaverse can enhance student engagement while reinforcing cultural identity. The Ministry of Culture's initiatives to promote Saudi heritage through digital means provide a strong foundation for integrating such content into educational practices.

Challenges in Infrastructure and Accessibility

Despite Saudi Arabia's advanced digital infrastructure, challenges related to equitable access and affordability persist. Studies such as Akyürek et al. (2024) emphasize the high costs associated with VR/AR tools and the infrastructure required to support metaverse applications. This review identifies public-private partnerships and government funding as critical strategies to bridge these gaps. Saudi Arabia's National Transformation Program, which prioritizes technological advancements, aligns well with these strategies, providing a framework to scale metaverse adoption (Coyne et al., 2021).

Digital Literacy: A Prerequisite for Success

The findings corroborate those of Meccawy (2023) and Selwyn and Facer (2021), who stress the importance of digital literacy among educators and students. Without targeted training programs, the benefits of metaverse technologies risk being undermined by a lack of proficiency in their use. Comprehensive professional development initiatives are necessary to equip educators with the skills to create and manage immersive learning experiences. Similarly, student training should focus on navigating and utilizing these technologies effectively, ensuring they maximize their academic potential.

Safeguarding Data Privacy and Ensuring Ethical Use

Concerns about data privacy and ethical use are central to the successful implementation of metaverse technologies, as noted by Zhou and Kim (2022). Saudi Arabia's National Cybersecurity Authority has made significant strides in aligning with international standards like GDPR. However, as Ajani (2023) highlights, ensuring transparency and real-time monitoring of data usage within virtual platforms is essential to maintaining trust among stakeholders. Clear policies on data minimization and user consent must be paired with robust enforcement mechanisms to address these concerns.

Linking Theory and Practice

The review's findings align with Tlili et al. (2022), who advocate for the metaverse as a pedagogical tool that bridges theoretical constructs with practical applications. The proposed framework integrates elements of gamification, adaptive learning, and collaborative projects, reflecting constructivist and experiential learning theories. These approaches not only foster deeper engagement but also prepare students for real-world challenges, particularly in STEM fields and vocational training.

Aligning with Vision 2030 Goals

The proposed model supports Vision 2030's emphasis on cultivating a knowledge-based society by fostering innovation, inclusivity, and technological advancement. The alignment of metaverse technologies with Saudi Arabia's cultural and educational priorities positions the Kingdom as a leader in educational innovation. Conferences like LEAP and initiatives such as the National Strategy for Data and Artificial Intelligence provide a supportive ecosystem for scaling these efforts.

CONCLUSION

The integration of metaverse technologies into Saudi Arabia's educational system represents a transformative opportunity to modernize learning in alignment with Vision 2030. By leveraging immersive virtual environments, the proposed framework addresses key challenges in engagement, inclusivity, and personalization while preserving cultural relevance. However, successful implementation requires targeted strategies to overcome challenges related to digital literacy, accessibility, and data security.

To fully realize the potential of metaverse-based education, it is essential to develop comprehensive training programs that equip educators and students with the technical and pedagogical skills needed to navigate and utilize these tools effectively. Embedding culturally relevant content within virtual environments is equally important, as it enhances student engagement and ensures alignment with Saudi societal values. Integrating Saudi heritage into educational modules, such as virtual tours and cultural simulations, can foster a deeper connection to local traditions while embracing technological advancement.

Ensuring robust cybersecurity and data privacy measures is critical to building trust among stakeholders. Saudi Arabia's advanced digital infrastructure and alignment with international standards, such as GDPR, provide a strong foundation for safeguarding student data. Transparent policies and real-time monitoring mechanisms must be prioritized to address concerns around

ethical data use. Accessibility and cost barriers must also be mitigated through strategic public-private partnerships and government funding to ensure equitable access to metaverse technologies across educational institutions.

Collaboration among policymakers, educators, and technology developers is essential to sustain innovation and scalability. By fostering partnerships and adopting localized approaches, Saudi Arabia can position itself as a global leader in educational technology. Through these strategic efforts, the Kingdom can create an adaptive, inclusive, and future-ready educational system that not only meets the demands of a digital age but also serves as a model for other nations.

REFERENCES

Ajani, Y. (2023). Reincarnation of libraries via metaverse: A pathway for a sustainable knowledge system in the digital age. Business Information Review, 40(4), 191-197. https://doi.org/10.1177/02663821231208044

Al-Adwan, A. S., Li, N., Al-Adwan, A., Abbasi, G. A., Albelbisi, N. A., & Habibi, A. (2023). Extending the technology acceptance model (TAM) to predict university students' intentions to use metaverse-based learning platforms. Education and Information Technologies, 28(11), 15381-15413. https://doi.org/10.1007/s10639-023-11816-3

Al Fraidan, A. (2024a). Anticipatory Thinking and AI-Driven Assessments: A Balanced Approach to AI Integration in Education Aligned with Saudi Vision 2030. African Journal of Biomedical Research. 27(3), 619-628. :https://doi.org/10.53555/AJBR.v27i3.2560

Al Fraidan, A. (2024b). Enhancing linguistic research through AI-powered reference management: A proposal for a voice-controlled academic assistant. Edelweiss Applied Science and Technology, 9(1), 1–9. https://doi.org/10.55214/25768484.v9i1.2240

Al Fraidan, A. (2024c). Direct vs. Indirect Listening Assessments: A Comparative Study of Gap-Filling and Cloze Tests on Social Media Using AI. Library Progress International.

Al Fraidan, A. & Olaywi, M. (2024). Scenarios to Implement Metaverse into the Saudi Educational System. Forum for Linguistic Studies, 6(4), 180–193. https://doi.org/10.30564/fls.v6i4.6853

Akyürek, S., Genç, G., Çalık, I., & Şengel, U. (2024). Metaverse in tourism education: A mixed method on vision, challenges and extended technology acceptance model. Journal of Hospitality, Leisure, Sport & Tourism Education, 35, 100503. https://doi.org/10.1016/j.jhlste.2024.100503

Buhalis, D., Lin, M., & Leung, D. (2022). Metaverse as a driver for customer experience and value co-creation: Implications for hospitality and tourism management and marketing. International Journal of Contemporary Hospitality Management, 35(2), 701-716. https://doi.org/10.1108/ijchm-05-2022-0631

Coyne, L., Merritt, T. A., & Takemoto, J. K. (2021). Using extended reality to promote team learning. In Educational Communications and Technology: Issues and Innovations (pp. 75-94). Springer. https://doi.org/10.1007/978-3-030-77614-5_5

Greenleaf, Graham, Global Data Privacy Laws 2019: 132 National Laws & Many Bills (February 8, 2019). (2019) 157 Privacy Laws & Business International Report, 14-18, Available at SSRN: https://ssrn.com/abstract=3381593

Griffin, W. C. (2021). The future of hospitality education: A reflection. Journal of Hospitality & Tourism Research, 45(5), 939-941. https://doi.org/10.1177/10963480211000828

Hadi, R., Melumad, S., & Park, E. (2023). The metaverse: A new digital frontier for consumer behavior. Journal of Consumer Psychology, 34(1), 142-166. https://doi.org/10.1002/jcpy.1356

Hong, H., Wang, X., Zhai, Y., & Hu, J. (2021). Evaluation of factors affecting student participation in peer-assisted English learning based on an online education platform. International Journal of Emerging Technologies in Learning (IJET, 16(11), 72-85. https://doi.org/10.3991/ijet.v16i11.23319

Kluge, M. G., Maltby, S., Keynes, A., Nalivaiko, E., Evans, D. J., & Walker, F. R. (2022). Current state and general perceptions of the use of extended reality (XR) technology at the University of Newcastle: Interviews and surveys from staff and students. Sage Open, 12(2). https://doi.org/10.1177/21582440221093348

1Md Nor, N., & Mahzan, N. A. (2023). General educators' attitude towards students with Autism Spectrum Disorder (ASD) in general education: A scoping review.

Meccawy, M. (2023). Teachers' prospective attitudes towards the adoption of extended reality technologies in the classroom: Interests and concerns. Smart Learning Environments, 10(1), 36. https://doi.org/10.1186/s40561-023-00256-8

Mystakidis, S. (2022). Metaverse. Encyclopedia, 2(1), 486-497. https://doi.org/10.3390/encyclopedia2010031

Okyere, E., Salusalu, M., Goundar, R., & Marfoh, K. (2022). What do university students say about online learning and the COVID-19 pandemic in central Fiji? A qualitative study. PLOS ONE, 17(8), e0273187. https://doi.org/10.1371/journal.pone.0273187

Park, S., & Kim, S. (2022a). Identifying world types to deliver gameful experiences for sustainable learning in the metaverse. Sustainability, 14(3), 1361. https://doi.org/10.3390/su14031361

Patiar, A., Kensbock, S., Benckendorff, P., Robinson, R., Richardson, S., Wang, Y., & Lee, A. (2021). Hospitality students' acquisition of knowledge and skills through a virtual field trip experience. Journal of Hospitality & Tourism Education, 33(1), 14-28. https://doi.org/10.1080/10963758.2020.1726768

Rahman, K., Shitol, S., Islam, M., Iftekhar, K., & Saha, P. (2023). Use of metaverse technology in the education domain. Journal of Metaverse, 3(1), 79-86. https://doi.org/10.57019/jmv.1223704

Singla, A., Gupta, N., Aeron, P., Jain, A., Garg, R., Sharma, D., … & Arya, V. (2023). Building the metaverse. Journal of Global Information Management, 31(2), 1-28. https://doi.org/10.4018/jgim.321755

Suhairi, L., Maryam, S., Kinara, H., Faudiah, N., & Gagarin, Y. (2023). The relationship between interest in following online learning with learning outcomes in basic Boga subjects department of culinary administration in vocational high schools. International Journal of Business Law and Education, 4(1), 141-148. https://doi.org/10.56442/ijble.v4i1.139

Tlili, A., Huang, R., Shehata, B., Liu, D., Zhao, J., Metwally, A., … & Burgos, D. (2022). Is metaverse in education a blessing or a curse: A combined content and bibliometric analysis. Smart Learning Environments, 9(1). https://doi.org/10.1186/s40561-022-00205-x

Wallace, R. (2003). Online learning in higher education: A review of research on interactions among teachers and students. Education Communication and Information, 3(2), 241-280. https://doi.org/10.1080/14636310303143

Wei, W. (2023). A buzzword, a phase or the next chapter for the internet? the status and possibilities of the metaverse for tourism. Journal of Hospitality and Tourism Insights, 7(1), 602-625. https://doi.org/10.1108/jhti-11-2022-0568

Zhou, B., & Kim, S.-Y. (2022). Building a smart education ecosystem from a metaverse perspective. Mobile Information Systems, 1-10. https://doi.org/10.1155/2022/1938329