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Developing a Performance Evaluation Framework Structural Model for Educational Metaverse †

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Abstract: In response to the transformative impact of digital technology on education, this study introduces a novel performance management framework for virtual learning environments suitable for the metaverse era. Based on the Structural Equation Modeling (SEM) approach, this paper proposes a comprehensive evaluative model, anchored on the integration of the Theory of Planned Behavior (TPB), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Community of Inquiry Framework (CoI). The model synthesizes five Key Performance Indicators (KPIs)—content delivery, student engagement, metaverse tool utilization, student performance, and adaptability—to intricately assess academic avatar performances in virtual educational settings. This theoretical approach marks a significant stride in understanding and enhancing avatar efficacy in the metaverse environment. It enriches the discourse on performance management in digital education and sets a foundation for future empirical studies. As virtual online environments gain prominence in education and training, this research study establishes the basic principles and highlights the key points for further empirical research in the new era of the metaverse educational environment.

Keywords: technology acceptance; virtual reality (VR); metaverse; avatars; training; education; performance management; structural equation modeling (SEM)

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1. Introduction

The 21st century has witnessed a significant transformation in the educational landscape, marked by the advent of artificial intelligence (AI) and the internet, subsequently leading to the metaverse—a complex digital universe characterized by avatar-based interactions. This paradigm shift presents unique challenges and opportunities for educational methodologies, particularly in the realm of performance assessment. A pertinent question emerges: how can academic achievement be effectively measured in this dynamic and multifaceted setting, where traditional assessment tools may not suffice?

This gap in performance evaluation methodologies, especially those suited to the distinctive learning context of the metaverse, is evident upon reviewing the existing academic literature. Traditional educational models often fall short of addressing the unique aspects of learning in avatar-centric environments. In response, this study proposes a conceptual framework based on the Structural Equation Modeling (SEM) approach. It integrates key theoretical frameworks—the Theory of Planned Behavior (TPB), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Community of Inquiry Framework (CoI)—to develop a multifaceted model for assessing academic avatar performances. As a result, the proposed model incorporates five Key Performance Indicators (KPIs): content delivery, student engagement, metaverse tool utilization, student performance, and adaptability, aiming to evaluate not only their individual impact, but also their collective influence on educational outcomes in the metaverse.

This paper introduces a novel perspective to educational assessment within the metaverse, blending traditional pedagogical principles with contemporary assessment methodologies. The proposed framework, comprehensive and adaptable, was specifically designed to evaluate academic avatar performances, highlighting the applicability of SEM in this emerging educational context. Beginning with an extensive literature review, this paper establishes a foundation for the development of specific KPIs oriented toward metaverse-based education. These KPIs, derived from both the literature and theoretical underpinnings, inform the selection and definition of variables within the SEM model. This approach not only provides a comprehensive framework for performance evaluations in virtual educational settings, but also offers valuable insights for Human Resource Management, particularly in designing and implementing effective performance management strategies in digitally transformed educational environments. Therefore, this research bridges a critical gap, informing both educational assessment practices and HRM strategies in the context of the evolving metaverse.

2. Literature Review

The advent of the metaverse has ushered in new frontiers in education, necessitating a re-evaluation of performance appraisal models in these virtual environments. This review explores current research on the metaverse's implications for education and the development of tailored performance evaluation models. It aimed to identify gaps in existing methodologies and introduce innovative appraisal approaches suited for virtual settings.

2.1. Transforming Education in the Digital Age

The onset of the COVID-19 pandemic served as an unprecedented catalyst in transforming the global educational landscape. As detailed in Reimers' extensive study [1], the abrupt closure of physical academic institutions and the consequent shift to remote learning necessitated the rapid adoption of digital solutions, highlighting the critical role of technology in maintaining educational continuity. This period not only showcased the resilience and adaptability of educational systems, but also accelerated the exploration and integration of advanced digital platforms, notably, the metaverse. This technological pivot, responding to the urgent needs of the time, set a new trajectory in educational methodology, emphasizing the importance of innovative, flexible, and interactive learning models [2–5].

In particular, in the wake of the pandemic, forward-thinking universities began to explore the potential of metaverse platforms, such as Spatial and Mozilla Hubs, to recreate their campuses in virtual realms [6]. These initiatives led to the creation of 'metaversities', digital twins of university spaces that offer immersive and interactive educational experiences. These virtual environments represent a paradigm shift in higher education, moving beyond the traditional classroom to embrace a new dimension of interactive and experiential learning. This innovative approach not only enhances student engagement, but also broadens the scope of pedagogical strategies, enabling educators to employ more dynamic and engaging methods that cater to the evolving needs of a diverse student population.

The alignment of technological evolution in both performance management and education reflects a broader trend toward digital integration. This convergence is reshaping the landscape of how we work, learn, and interact in virtual environments. The shift toward the metaverse in education is parallel to the transformation in performance management strategies, where digital tools and virtual interactions are becoming increasingly integral [7–9]. This trend signifies a shift toward more innovative, flexible, and inclusive approaches in both educational and professional settings, acknowledging the increasing importance of virtual environments in daily life and interactions.

2.2. Redefining Performance Management and Educational Paradigms in the Metaverse Era

The evolution of Human Resources, particularly in performance management, has significantly shifted from traditional models to more advanced, technology-driven practices. This shift, as highlighted by DeNisi and Murphy [10], moves away from annual reviews and toward continuous, multifaceted feedback systems, including 360-degree assessments. The integration of artificial intelligence (AI) and data analytics, along with agile methodologies, as noted by Otley [7], Varma et al. [8], and Schrøder-Hansen and Hansen [9], marks a significant change in aligning employee goals with organizational objectives. Despite these advancements, such models might not fully cater to the unique dynamics of virtual environments, particularly those in the metaverse.

The metaverse, emerging as a blend of shared, 3D virtual spaces, has been expanding upon Neal Stephenson's 1992 concept. It serves as a nexus for virtual reality (VR), augmented reality (AR), and emergent technologies like 5G, AI, blockchain, and The Internet of Things (IoT), influencing various domains, including education, as indicated by researchers [11–14]. However, integrating the metaverse into education and performance management systems (PMSs) introduces unique challenges, such as adapting to virtual roles and dynamics and addressing infrastructural and ethical concerns, as highlighted by Rospigliosi [15] and Tsappi and Papageorgiou [16]. In addition, the integration of VR technologies has not only enriched the educational landscape, but also necessitated a re-evaluation of pedagogical strategies to fully harness these advancements' potential. This evolution underscores the growing importance of adapting teaching and learning methodologies to align with the interactive and immersive capabilities of the metaverse, thereby enhancing both student engagement and learning outcomes [17]. Current performance management models may not adequately address these metaverse-specific challenges, highlighting a significant gap [16].

Recent studies in game-based learning and serious games within virtual environments underscore the transformative potential of these methodologies in enhancing student engagement and learning outcomes. The incorporation of immersive, interactive elements and the application of learning analytics provide critical insights into learner behavior and preferences, facilitating personalized and effective educational experiences. These findings support the development of innovative performance management frameworks in virtual learning environments, such as the metaverse, by highlighting the importance of engagement, interaction, and the utilization of analytics to assess and improve educational strategies [18–20]. The literature not only validates the relevance of integrating game-based elements into virtual learning, but also emphasizes the necessity for comprehensive evaluation and adaptation mechanisms to optimize learning in these advanced digital contexts.

Specifically, Mosteanu 2021 [21] provides an in-depth analysis of online teaching-learning-assessment activities, offering valuable insights into the university environment. While significant for traditional online settings, this study may not fully capture the complexities of the metaverse and virtual education. Its focus on student engagement and active participation, though crucial, underscores the need for educational strategies adaptable to the metaverse's dynamic landscape. Moreover, Maimela and Samuel [22] offered critical insights into the implementation of PMSs in distance learning institutions. Their study, involving a survey of 492 academic staff members, revealed general satisfaction with PMS implementation but suggested revising incentive mechanisms, particularly relevant for virtual education settings and the metaverse.

Further, Hedrick et al. [23] explored VR platforms such as the 'Meta Horizon Workrooms' for immersive classroom experiences, evaluating their effectiveness in virtual instruction and their impact on student engagement and academic performance. While highlighting the transformative potential of VR technology, this research also points to gaps in current performance appraisal models in VR-based educational settings. Shu and Gu's 2023 study on the Edu-metaverse-based smart education model emphasizes performance assessments as a key component, involving both formative and summative assessments.

This research is instrumental in understanding the Edu-metaverse's impact on student engagement and learning outcomes but also indicates the need for more comprehensive assessment models in metaverse education [24].

Moreover, the METAEDU questionnaire, developed by López-Belmonte et al. [25], provides a tool for evaluating educational experiences in the metaverse. While it offers a significant step in assessment, it also uncovers limitations in current evaluation methods, particularly in capturing the depth of interactions and learning experiences within metaverse environments. Finally, the study by Muthmainnah, Al Yakin, and Seraj [26] shed light on the positive effects of metaverse technology on student engagement and academic performance. However, the study's reliance on self-reported measures and its focus on a specific demographic in Dubai may have limited the generalizability of the findings, indicating the need for more diverse and comprehensive research methodologies [26].

A survey designed to investigate the factors influencing the educational metaverse's performance, emphasizing an extended UTAUT model, highlights how performance expectancy, effort expectancy, social influence, and facilitating conditions significantly enhance learners' satisfaction. Moreover, it notes the critical role of satisfaction in fostering continued usage intention. Importantly, it also discusses the negative impact of perceived risks on usage intention, illustrating a comprehensive view of the dynamics at play in adopting educational metaverse platforms [27]. However, this study offers a broader, more nuanced framework for understanding and measuring educational performance in the metaverse, suggesting a more comprehensive approach than the survey by Teng et al. [27].

Another study has delved into the application of SEM to develop a structural model for performance in the educational metaverse, identifying critical variables meticulously and developing a scale to measure learners' experiences and emphasizing factors like immersion and interaction quality, which are crucial for engaging and effective learning in virtual settings [28]. In contrast, this paper advances a performance management framework structural model that methodically integrates theoretical models and KPIs for assessing educational outcomes. This framework's strength lies in its comprehensive approach, combining psychological, technological, and pedagogical perspectives to provide a multifaceted evaluation of educational effectiveness in the metaverse.

In conclusion, the integration of the metaverse into educational settings requires innovative performance appraisal models that can effectively address its unique challenges. These models should consider various factors like technological proficiency, curriculum innovation, and adherence to ethical practices. The existing gap in performance appraisal methods, as discussed by researchers, emphasizes the need for context-sensitive and adaptive approaches that can accommodate the dynamics of academic performance in virtual learning environments [15,16,29–31].

2.3. Integrating Key Performance Indicators and Metaverse Dynamics in Modern Educational Systems

Key Performance Indicators (KPIs) are essential, quantifiable measures used to evaluate the success of an organization, employee, or other entity in achieving key business objectives. The nature and focus of KPIs vary across contexts. For instance, in education, KPIs might include student graduation rates, post-graduation employment rates, student satisfaction scores, or research output. In a metaverse educational environment, KPIs are evolving to encompass metrics specific to virtual learning, such as engagement levels with virtual content, the effectiveness of virtual interactions, and the usability of virtual learning tools [16,32].

The importance of effective management systems, particularly through the use of KPIs, is well recognized in higher education. Safonov et al. [33] delved into various KPI types—result, expenditure, performance, productivity, and efficiency indicators—utilized in university operations. They emphasized the need for a comprehensive approach combining process modeling, performance measurement, data mining models, and data technologies, especially pertinent to medical universities. The Balanced Scorecard was suggested as a foundational model for assessing higher education institutions, suitably tailored to their organizational and administrative frameworks [34–39].

Further, Shaulska et al. [40] addressed the challenges of implementing KPI systems in universities, including issues like irrational behavior and resistance to change among staff. They recommend adopting the Balanced Scorecard approach for the educational sector to align KPIs with strategic objectives, highlighting the need for a reflexive and active management culture within universities for effective strategic management. Similarly, Mourato and Patrício [41] investigated performance and control systems in higher education institutions in Portugal and The Netherlands, noting the significant role played by the Balanced Scorecard, Total Quality Management, ISO standards, and the European Foundation for Quality Management in these institutions' management processes.

Furthermore, Hutaibat et al. [42] explored performance management systems (PMSs) in UK universities through the concept of 'performance habitus', combining academic values and managerial practices. This model integrates academic assessments, financial health, and cultural expectations, underscoring the importance of aligning strategy, culture, and performance expectations. However, the integration of the metaverse into educational contexts demands a re-evaluation of these traditional models. The metaverse's unique virtual interactions and work dynamics call for more adaptive performance appraisal approaches. A systematic literature review [16] argues that while models like the Balanced Scorecard are effective in structured environments, the metaverse requires flexibility and the integration of virtual and real-world performance metrics.

It is evident that in a metaverse setting, academic staff face challenges such as adapting to technological demands, managing communication without non-verbal cues, handling digital avatars, and addressing privacy and data security concerns. The immersive nature of the metaverse, potential technostress, and the blurred boundaries between work and personal life present significant concerns. Additionally, equitable access to technology, cultural and social diversity, and the need for continuous professional development are crucial considerations. Traditional metrics for evaluating academic performance may not fully apply in the metaverse, indicating the necessity for new assessment criteria that reflect these unique challenges.

Overall, the integration of the metaverse into educational settings requires a careful rethinking of performance appraisal models. These models must adapt to the technological, communicative, and cultural dynamics of virtual environments. Developing new KPIs suitable for metaverse-based education is essential, ensuring that PMSs remain effective, adaptable, and relevant in these evolving educational landscapes. For a successful transition to the metaverse educational realm, it is necessary to encapsulate the multiple factors involved into a comprehensive conceptual framework model. Such a model is discussed in the next section.

2.4. Developing an Educational Metaverse Performance Evaluation Conceptual Framework

A conceptual framework in research acts as a structured, theoretical guide that provides a clear illustration of the concepts, theories, and variables involved, as well as the relationships among them [43]. In this study, a conceptual framework was pivotal for understanding and evaluating the performance of academic staff in the metaverse. It offers both theoretical depth and practical guidance, ensuring that performance appraisal methods are relevant, effective, and adaptable to the nuances of virtual learning environments.

Grounded in the literature review above, a robust performance appraisal model is proposed, integrating the Theory of Planned Behavior (TPB) [44,45], the Unified Theory of Acceptance and Use of Technology (UTAUT) [26,46], and the Community of Inquiry Framework (CoI) [47,48]. This multifaceted approach evaluates academic staff performances in the metaverse, with a focus on avatar utilization (as shown in Table 1). The proposed integration facilitates a nuanced understanding of the interplay between theoretical constructs and their practical application within the metaverse's educational environment.

Table 1. KPI-based approach.

KPIs	Theory/ Framework	Definition	Application in Metaverse Educational Environment
User Engagement	TPB and UTAUT	TPB: Behavior is driven by intentions influenced by attitudes, subjective norms, and perceived control. UTAUT: Technology use is influenced by performance/effort expectancy, social influence, and facilitating conditions.	A positive attitude and high-performance expectancy enhance engagement. Understanding students' intentions, attitudes, peer influence, and perceived ease of use of avatars.
Learning Outcomes	CoI	Effective online learning characterized by social, cognitive, and teaching presence.	Cognitive presence is crucial for effective learning. Enhancing this in avatars improves educational outcomes and fosters meaningful learning.
Usability and User Experience	UTAUT	User acceptance and technology use are influenced by performance expectancy, effort expectancy, social influence, and facilitating conditions.	Ease of use and positive user experience are key. Effort expectancy leads to better acceptance and usage of academic avatars.
Interactivity	CoI	Effective online learning characterized by social, cognitive, and teaching presence.	Social and teaching presence influence interactivity. Strong community sense and authentic teaching through avatars encourage active engagement.
Technological Efficiency	UTAUT	User acceptance and technology use are influenced by performance expectancy, effort expectancy, social influence, and facilitating conditions.	Robust and user-friendly technical infrastructure is essential. Facilitating conditions impact the adoption and effective use of avatars.

The Key Performance Indicators (KPIs) outlined in Table 1 are central to the proposed model. Each KPI aligns with respective theories and frameworks, providing a comprehensive evaluation tool. For example, user engagement, underpinned by the Theory of Planned Behavior (TPB) and the Unified Theory of Acceptance and Use of Technology (UTAUT), is defined as behavior driven by intentions influenced by attitudes, subjective norms, and perceived control. This KPI emphasizes the importance of a positive attitude and high-performance expectancy in enhancing engagement in the metaverse, focusing on understanding students' intentions, attitudes, peer influence, and perceived ease of use of avatars. Similarly, learning outcomes, rooted in the Community of Inquiry (CoI) framework, highlight the role of social, cognitive, and teaching presence in effective online learning. This KPI underscores the significance of cognitive presence in fostering meaningful learning experiences and enhancing educational outcomes through avatars. Usability and user experience, based on the UTAUT, emphasizes the importance of ease of use and positive user experience in promoting the acceptance and usage of academic avatars.

The interactivity KPI, also derived from the CoI, illustrates how social and teaching presence influences interactivity, fostering a strong community sense and authentic engagement through avatars. Technological efficiency, aligned with the UTAUT, stresses the need for a robust and user-friendly technical infrastructure to support the adoption and effective use of avatars. The shift to metaverse environments requires a significant re-evaluation of existing performance appraisal methods, demanding a broader spectrum of performance indicators, including job satisfaction, employee–avatar interactions, and skills necessary for effective virtual communication and avatar management. Challenges unique to the metaverse, such as technostress, techno-spatial intrusion, and techno-addiction, need to be integrated into appraisal metrics.

The proposed model, diverging from traditional appraisal methodologies, encompasses a wide range of factors from psychological motivations to practical usability aspects.

It provides insights into user engagement, the significance of cognitive and teaching presence, and the importance of usability and technological infrastructure. Consequently, it ensures that staff well-being and professional development are prioritized in the appraisal process, facilitating targeted interventions and significantly enhancing engagement, enriching learning experiences, and amplifying overall effectiveness in virtual educational settings.

As shown in Figure 1, the inter-relationships between the theoretical constructs of the Theory of Planned Behavior (TPB), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Community of Inquiry Framework (CoI) are visually correlated with the corresponding Key Performance Indicators (KPIs) to demonstrate their impactful connections within the metaverse's educational context. The diagram, rooted in the extensive literature review of Section 2, clarifies the presumed influence of these theories on specific KPIs, which is essential for understanding and enhancing academic staff performance in the metaverse.

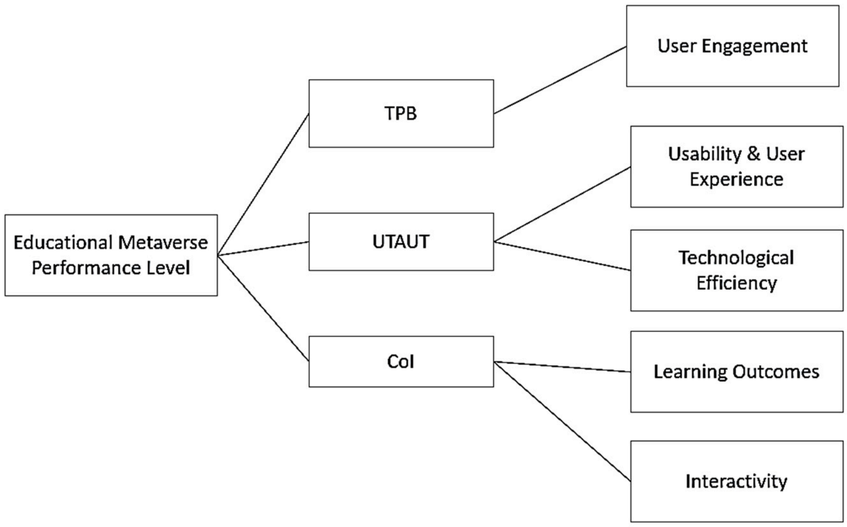

Figure 1. An educational metaverse performance evaluation conceptual framework.

The TPB's influence on user engagement is underscored by Ajzen's foundational work [49], which posits that an individual's intention to engage is informed by attitudes, subjective norms, and perceived behavioral control. This correlation suggests that in cultivating these factors, there is potential to significantly heighten engagement in virtual learning environments. The UTAUT model's links to usability and user experience and technological efficiency are illuminated, reflecting the premise that acceptance and the effective use of technology hinge on performance expectations, effort expectations, social influence, and facilitating conditions [50]. These elements are pivotal for maximizing the functionality of educational tools within the metaverse, indicating that fine-tuning these variables can lead to enhanced learning experiences. Furthermore, the CoI framework's association with learning outcomes and interactivity emphasizes the construction of a supportive educational community through social, cognitive, and teaching presence. These connections highlight the framework's role in fostering a collaborative and immersive educational experience, which is vital for achieving meaningful learning outcomes and promoting active engagement in the metaverse [51–53].

The schematic representation in Figure 1 serves as a visual aid and as the theoretical backbone of this study, illustrating how established theories can be translated into quantifiable outcomes for evaluating and improving academic performance in an internet virtual domain. The frameworks TPB, UTAUT, and CoI support the development of Key Performance Indicators (KPIs), which then relate to key variables. The frameworks provide theoretical foundations and principles that guide the identification and formulation of KPIs. These KPIs, in turn, are used to measure and assess specific variables, which are critical aspects of user interaction and educational effectiveness in the metaverse. This flow from frameworks to KPIs to variables ensures a structured and theory-informed approach to evaluating academic avatar performances in virtual learning environments. In essence, Figure 1 offers a roadmap for empirical research and the practical application of a performance appraisal system designed to meet the nuanced demands of metaverse-based educational environments.

3. Developing a Model for Evaluating Performance in the Metaverse Educational Realm

A systematic literature review was employed to identify the principal factors affecting performance in an educational metaverse setting. These factors were then combined into a causal model to be tested using the Structural Equation Modeling (SEM) method. This study utilized comprehensive databases, including Google Scholar, Springer, Scopus, ACM, and IEEE Xplore, chosen for their extensive coverage in educational technology and metaverse research. The search, limited to English articles from 2000 to 2024, involved keyword combinations like 'Metaverse', 'Avatar-mediated education', 'Academic avatar performance', and others. These keywords were strategically selected to encompass the study's multifaceted nature, integrating approaches from Structural Equation Modeling and educational theories and technology. Boolean operators and filters were used to refine the search to focus on specific publication types and research domains.

Articles were selected based on specific criteria, with inclusion focused on SEM applications in educational technology and metaverse contexts, and exclusion targeting non-peer-reviewed articles and those misaligned with the study's themes. This dual-filter approach ensured the dataset's relevance and quality. The quality appraisal involved a template for reviewing authorship, publication year, purpose, methodology, findings, and relevance, assessing methodological rigor, research question alignment, and the impact factor of publication sources for thoroughness and academic integrity. Data extraction and synthesis were performed independently by researchers, resolving disagreements through expert consultation, minimizing bias and ensuring balanced data interpretation.

A thematic analysis revealed key themes, providing insights into the field's research state. The program's advanced capabilities enabled a detailed analysis of measurement and structural models. The causal model's empirical validation was pursued through Structural Equation Modeling (SEM), with surveys aimed at both students and academics to enhance the model's validity and practicality. The survey design, implementation, and analysis methodology will be thoroughly detailed in future publications. This structured plan for empirical validation in a metaverse-based educational setting, particularly using the Spatial platform at Neapolis University Pafos (NUP), includes a case study and a performance evaluation phase to measure the environment's impact on learning outcomes and engagement.

Metaverse Variable Interdependence and the Structural Equation Modeling (SEM) Approach

The Structural Equation Modeling (SEM) method is a cornerstone in contemporary research methodologies, particularly notable for its proficiency in examining intricate, interdependent relationships. This attribute is crucial in the multifaceted realm of the metaverse, as posited by Dragan and Topolšek in 2014 [54]. Within the metaverse, variables such as user engagement, content delivery, and tool utilization present a level of complexity that surpasses the capacities of traditional regression models. SEM's prowess lies in its ability to model elusive, theoretical constructs like the 'sense of presence' in virtual spaces or the concept of 'avatar identity', which evades direct measurement. Such modeling is achieved through observable measurable indicators, like survey responses, enabling a nuanced and comprehensive understanding of the metaverse's dynamics.

The task of pinpointing specific variables from Key Performance Indicators (KPIs) is steered by the defined objectives and inherent characteristics of each KPI, a process elucidated by Marr in 2021 and further explored by Gunduz et al. in 2023 [55]. In the educational sphere of the metaverse, the relationships among key variables are notably complex. To unravel these intricacies, frameworks such as the Theory of Planned Behavior (TPB), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Community of Inquiry (CoI) are employed. Each of these frameworks provides a unique lens through which a set of interwoven variables can be understood and analyzed. The proposed latent variables are shown in Figure 2.

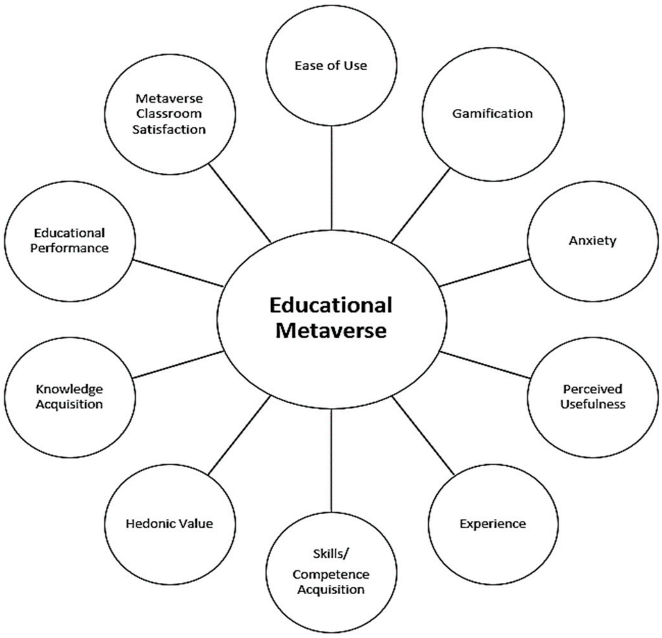

Figure 2. Derived latent variables based on TPB, UTAUT, and CoI.

In order to assess the various dimensions of educational performance within the metaverse, the study identified several latent variables, as detailed in Table 2. These variables, including 'Ease of Use', were derived from theoretical frameworks such as the TPB, UTAUT, and CoI. For example, consider the proposed latent variable 'Ease of Use', which affects user engagement, usability, and user experience, as well as learning outcomes. It is expected that a metaverse platform that is intuitive and easy to navigate enhances user engagement by simplifying the learning process. This, in turn, improves usability and user experience, contributing positively to learning outcomes. This relationship echoes the principles of the TPB, which focuses on behavior and intention, the UTAUT's emphasis on technology adoption and acceptance, and the CoI's highlight on cognitive presence in learning environments.

Table 2. Latent variables.

Latent Variable	Framework	KPI	Explanation
Ease of Use: Refers to how user friendly and straightforward the metaverse platform is. It is hypothesized that easier-to-use platforms enhance user engagement, usability, and learning outcomes.	TPB	User Engagement	Influences attitudes toward technology, affecting intention to use.
	UTAUT	Usability and User Experience	Significantly impacts user acceptance and technology use.
	CoI	Learning Outcomes	Facilitates better focus on learning by enhancing cognitive presence.
Anxiety: Describes the level of discomfort or apprehension users may feel in the metaverse. High anxiety can negatively impact engagement, usability, and interactivity.	TPB	User Engagement	Negatively impacts attitudes toward technology, reducing intention to use.
	UTAUT	Usability and User Experience	High levels negatively impact perceived ease of use and effort expectancy.
	CoI	Interactivity	Affects social presence, potentially reducing participation in the metaverse.

Table 2. *Cont.*

Latent Variable	Framework	KPI	Explanation
Perceived Usefulness: The degree to which users believe that using the metaverse will enhance their learning.	TPB	Learning Outcomes	Shapes attitudes and intentions, increasing the likelihood of engagement.
	UTAUT	Learning Outcomes	Direct link to performance expectancy, influencing metaverse use.
	CoI	Learning Outcomes	Enhances cognitive presence, impacting user engagement with content.
Knowledge Acquisition: The process of gaining new information or understanding through the metaverse.	TPB	Learning Outcomes	Influences intention to use the metaverse for effective knowledge acquisition.
	UTAUT	Learning Outcomes	Perceived as a tool for effective knowledge acquisition, increasing usage.
	CoI	Learning Outcomes	Aligns with cognitive presence, enhancing learning.
Skills/Competence Acquisition: Developing new abilities or expertise within the metaverse setting.	TPB	Learning Outcomes	Positive expectations about skill development enhance the intention to use.
	UTAUT	Learning Outcomes	Beliefs about skill development through metaverse enhance usage.
	CoI	Learning Outcomes	Aligns with cognitive presence, impacting skill acquisition.
Experience: Experience in the metaverse can influence engagement, usability, and interactivity, enhancing the overall educational experience.	TPB	User Engagement	A positive experience leads to a favorable attitude and higher intention to use.
	UTAUT	Usability and User Experience	Enhances user experience, increasing usage intention and satisfaction.
	CoI	Interactivity	Closely tied to teaching presence, influencing content delivery.
Hedonic Value: The intrinsic enjoyment and emotional gratification from metaverse experiences.	TPB	User Engagement	Enhances emotional engagement and satisfaction in the metaverse.
	UTAUT	Usability and User Experience	Improves usability by aligning with user expectations for pleasure and enjoyment.
	CoI	Interactivity	Directly impacts satisfaction with the learning experience in the metaverse.
Gamification: Involves applying game design elements in educational settings to increase engagement and learning effectiveness.	TPB	User Engagement	Enhances user interaction and enjoyment, which can lead to increased intention to use the platform.
	UTAUT	Usability and User Experience	Gamification can improve the perceived ease of use by making the experience more engaging, thus influencing usage.
	CoI	Interactivity	Gamified elements can enhance the teaching presence and active learning in the classroom.
Educational Performance: The effectiveness of educational interventions in the metaverse in improving knowledge, abilities, and academic results.	TPB	User Engagement	Directly influenced by the perceived ease of use and enjoyment, leading to better performance.
	UTAUT	Learning Outcomes	Perceived improvement in skills and knowledge through the use of technology can enhance academic performance.
	CoI	Learning Outcomes	A positive correlation between student satisfaction in the metaverse classroom and their academic performance.

Table 2. *Cont.*

Latent Variable	Framework	KPI	Explanation
Metaverse Classroom Satisfaction: The level of contentment and fulfilment users feel with their metaverse educational experience.	TPB	User Engagement	Satisfaction influences overall attitude, affecting engagement.
	UTAUT	Usability and User Experience	Satisfaction leads to the continued and effective use of the metaverse.
	CoI	Interactivity	Results from effective social, cognitive, and teaching presence.

Conversely, 'Anxiety' is a negative variable also derived from the three basic frameworks (TPB, UTAUT, and CoI). Within the metaverse realm, elevated anxiety levels can impede user engagement, detrimentally affect usability and user experience, and hinder interactivity. A complex VR environment, for instance, might be overwhelming for users, leading to anxiety that diminishes their engagement and interaction within the platform. This reflects the TPB's focus on the influence of attitudes on technology use, UTAUT's emphasis on effort expectancy, and CoI's consideration of social presence. Moreover, 'Perceived Usefulness' directly influences 'Learning Outcomes' across all three frameworks. When users perceive a metaverse tool as instrumental for their learning, their engagement and efficacy in using it are enhanced, thereby improving learning outcomes. For example, a virtual simulation that is perceived as valuable for understanding complex scientific concepts can lead to higher cognitive presence and deeper learning, aligning with the principles of the TPB, UTAUT, and CoI.

'Experience in the Metaverse' influences 'User Engagement', 'Usability and User Experience', and 'Interactivity', as outlined by the TPB, UTAUT, and CoI. An experienced user is more likely to engage deeply, find the platform more usable, and participate actively. For instance, educators adept in metaverse tools can create more interactive and engaging virtual lessons, leveraging their deep understanding of the platform's capabilities. 'Knowledge Acquisition' and 'Skills/Competence Acquisition' are closely linked to 'Learning Outcomes' under all frameworks. The process of acquiring knowledge and skills, such as learning a new language through an immersive VR experience, is augmented when the platform aligns with cognitive presence (CoI), is perceived as useful (TPB), and meets performance expectancy (UTAUT).

The 'Hedonic Value' variable emerges as a crucial element interwoven with the theoretical frameworks—the Theory of Planned Behavior (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), and Community of Inquiry (CoI). Within the TPB framework, the Hedonic Value significantly enhances emotional engagement and satisfaction in the metaverse, suggesting that the intrinsic enjoyment and pleasure derived from the metaverse experience directly influence users' attitudes, intentions, and subsequent behaviors. In the UTAUT context, the Hedonic Value plays a pivotal role in improving usability and user experience by meeting user expectations for pleasure and enjoyment, thereby facilitating greater acceptance and use of the technology. Lastly, under the CoI framework, the Hedonic Value is seen to directly impact metaverse classroom satisfaction, indicating that the enjoyable and emotionally gratifying aspects of the metaverse significantly contribute to creating a more engaging and satisfying classroom setting. This comprehensive integration of the Hedonic Value with these frameworks provides a nuanced understanding of how emotional and experiential factors shape user interactions and learning outcomes in the metaverse educational environment.

'Gamification' refers to the use of game design elements in non-game contexts, including the integration of game mechanics, dynamics, and frameworks into the educational setting to enhance the learning experience, increase student engagement, and motivate participation. Within the context of the metaverse, gamification might encompass elements such as points, badges, leaderboards, challenges, and interactive scenarios that make the learning process more engaging and enjoyable. Gamification within the educational metaverse environment integrates game-like elements to foster engagement and learning. Under the Theory of Planned Behavior (TPB), it is theorized that gamification enhances the emotional engagement of learners, thereby positively influencing their attitudes toward the metaverse and increasing their intention to use it.

The Key Performance Indicator (KPI) for gamification in this context is 'User Engagement', which gauges the extent to which learners interact with the metaverse platform. In the Unified Theory of Acceptance and Use of Technology (UTAUT), gamification is posited to improve usability and user experience by meeting learners' expectations for an enjoyable and immersive experience, which in turn facilitates greater acceptance and use of the metaverse for educational purposes. Here, the KPI would be 'Usability and User Experience', reflecting the ease with which users can navigate and engage with the platform. Within the Community of Inquiry (CoI) framework, gamification is seen as a tool used to enhance teaching presence and active learning, which are vital for an engaging educational experience. The KPI related to this would be 'Interactivity', indicating the level of dynamic interaction and involvement in the learning process.

Additionally, 'Educational Performance' refers to the measurable outcomes of learning processes, which can include academic achievement, skill acquisition, and competence development within the metaverse educational environment. It is a broad term that captures the effectiveness of educational interventions and technologies in improving students' knowledge, abilities, and overall academic results. Educational performance in the metaverse measures the efficacy and outcomes of learning interventions. According to the TPB, educational performance is likely influenced by learners' attitudes toward the technology, shaped by their experiences, including gamification aspects. Positive attitudes may lead to better academic performance, with 'User Engagement' serving as the KPI used to monitor this relationship. In the UTAUT framework, educational performance is associated with performance expectancy, where if the metaverse is perceived to be effective in improving skills and knowledge, this will likely lead to enhanced academic performance. The KPI here is 'Learning Outcomes', reflecting the perceived improvement in educational achievements due to the use of the metaverse. Within the CoI framework, educational performance is closely linked to learners' satisfaction in the metaverse classroom, resulting from effective social, cognitive, and teaching presence. The corresponding KPI is also 'Learning Outcomes', measuring the impact of the metaverse's educational environment on students' satisfaction and academic results. The final variable, 'Metaverse Classroom Satisfaction', influenced by all three frameworks, impacts 'User Engagement', 'Usability and User Experience', and 'Interactivity'. Satisfaction in a metaverse classroom setting can lead to higher engagement, better usability experiences, and increased interactivity, as seen in well-designed virtual classrooms where students feel content with the immersive experience, leading to active participation and effective learning. Finally, in acknowledging the research, it is essential to recognize that technology use may vary based on sex and age [56,57]. Furthermore, the availability of technology can also influence usage behavior [58]. To account for these variations, it is crucial to control for these variables in research, and this is achieved by asking participants to report their sex and age.

To enhance the understanding of the metaverse's educational dynamics, this study meticulously explored the inter-relationships among pivotal variables. This study delved into the relationships between key variables such as ease of use, anxiety, perceived usefulness, gamification, experience, Hedonic Value, knowledge acquisition, skills/competence acquisition, educational performance, and metaverse classroom satisfaction, highlighting how they influence each other in the context of a metaverse learning environment. The hypotheses suggest that a platform's ease of use reduces user anxiety and enhances its perceived usefulness. Incorporating gamification is posited to increase the platform's perceived educational value.

Further, it is hypothesized that a user-friendly interface reduces anxiety, contributing to a more enjoyable experience (Hedonic Value). Additionally, it is proposed that prior experience with the platform influences its perceived usefulness. The acquisition of knowledge and skills is driven by the platform's perceived utility, affecting learning outcomes. Furthermore, educational performance, influenced by the acquisition of knowledge and skills, impacts satisfaction within the metaverse classroom. This framework aims to elucidate how these various factors interconnect and influence educational effectiveness and user satisfaction in virtual learning environments.

Ease of use is presented as a cornerstone variable that impacts both anxiety and perceived usefulness, where an intuitive platform is linked to lower anxiety and a higher perception of utility. Gamification, a key aspect of modern educational approaches, influences the perceived usefulness, suggesting that when educational platforms incorporate gamified experiences, they are perceived as more valuable. Hedonic Value is shown to be affected by the ease of use and anxiety, indicating that user-friendly interfaces that reduce anxiety can lead to a more pleasurable experience. Experience acts as an intermediary that is shaped by ease of use and influences perceived usefulness, reinforcing the idea that ease of use can enhance the user experience, which, in turn, can make the platform seem more useful.

The variables knowledge acquisition and skills/competence acquisition are driven by perceived usefulness, highlighting the direct impact of a platform's perceived utility on learning outcomes. Educational performance is influenced by the knowledge and skills gained, underlining the progression from useful interactions to tangible learning outcomes. Metaverse classroom satisfaction is seen as a result of the educational performance, suggesting that as learners perform better, their satisfaction with the metaverse classroom increases. Lastly, this study acknowledges the need to control for demographic factors such as sex and age to understand their moderating effects on these relationships, pointing toward personalized educational experiences [56–58].

The derived latent variables in the educational metaverse performance system can now be drawn as a proposed causal model ready to be tested under the SEM approach. Figure 3 shows the proposed configuration of the latent variables as a series of causes and effects, as well as plausible moderating and control variables. In SEM, the structural model is used to hypothesize and test the relationships between latent (unobserved) variables. These latent variables are theoretical constructs that are not directly measurable but are inferred from observed variables [54]. In the proposed causal model, the latent variables (see Figure 2) pertain to aspects of user interaction and learning within the metaverse; they were designed to evaluate the dynamics of academic avatar performance in virtual educational settings. These variables, derived from the Theory of Planned Behavior (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), and Community of Inquiry Framework (CoI), could offer insights into user engagement, technology adaptation, educational efficacy, and satisfaction in the metaverse classroom. In this way, these variables were incorporated to construct the proposed comprehensive model for assessing and enhancing learning experiences and outcomes in virtual educational environments.

Concerning the inherent adaptability to the rapidly evolving landscape of virtual learning environments, by leveraging Structural Equation Modeling (SEM) to integrate various theoretical frameworks such as the Theory of Planned Behavior (TPB), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Community of Inquiry (CoI), the proposed framework model was positioned to dynamically respond to emerging technologies. This approach facilitates empirical validation through mixed method research, incorporating both quantitative and qualitative data to continually refine and enhance the model's effectiveness. Through a focus on Key Performance Indicators (KPIs) like user engagement, learning outcomes, and technological efficiency, the methodology ensures that the model remains relevant and impactful in the face of technological advancements, thereby maintaining its applicability and effectiveness in diverse educational contexts.

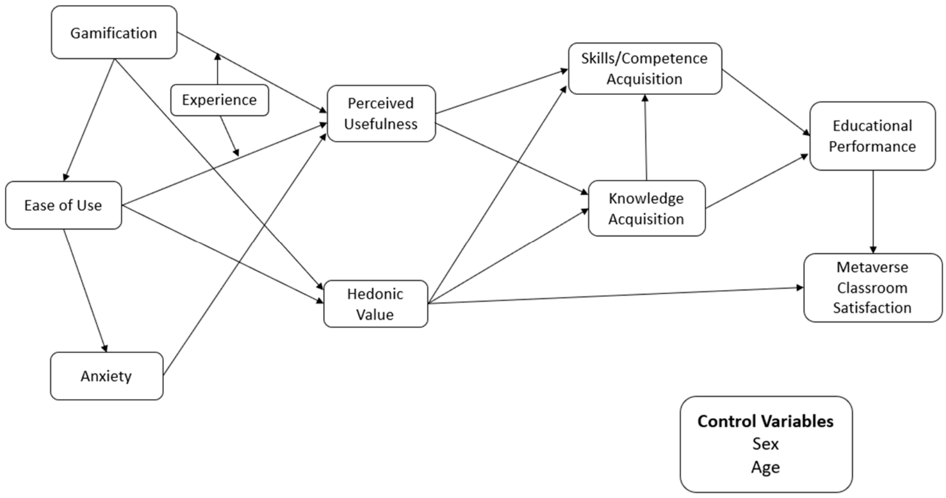

Figure 3. Latent variables in the metaverse educational classroom.

The model was prepared for real-life application in a case study at Neapolis University Pafos, utilizing the Spatial platform to create a metaverse-based classroom. This phase will enhance the data collection plan with immersive experiences, capturing comprehensive data on student engagement, learning outcomes, and interaction patterns through surveys, observation, and platform analytics. This versatile platform hosts a wide array of 3D games accessible across various devices including desktop, mobile, and VR, without any download requirements. This wide accessibility, coupled with its capacity for creating 3D environments, renders it an exemplary platform for the empirical evaluation of this study [59]. This involves enhancing the data collection plan with experiences, as shown in the designed metaverse classroom in Figure 4. The metaverse classroom setting would capture comprehensive data on student engagement, learning outcomes, and interaction patterns via surveys, direct observation, and an analysis of platform analytics. SEM analysis could then be used to investigate the nuanced relationships between metaverse educational affordances and academic performance, assessing construct reliability, validity, and model fit with advanced statistical tools. The relevance of virtual environments for enhancing operational efficiency and employee engagement, as explored by Zvarikova et al. [60] in the context of virtual human resource management, underscores the transformative potential of these technologies beyond educational settings.

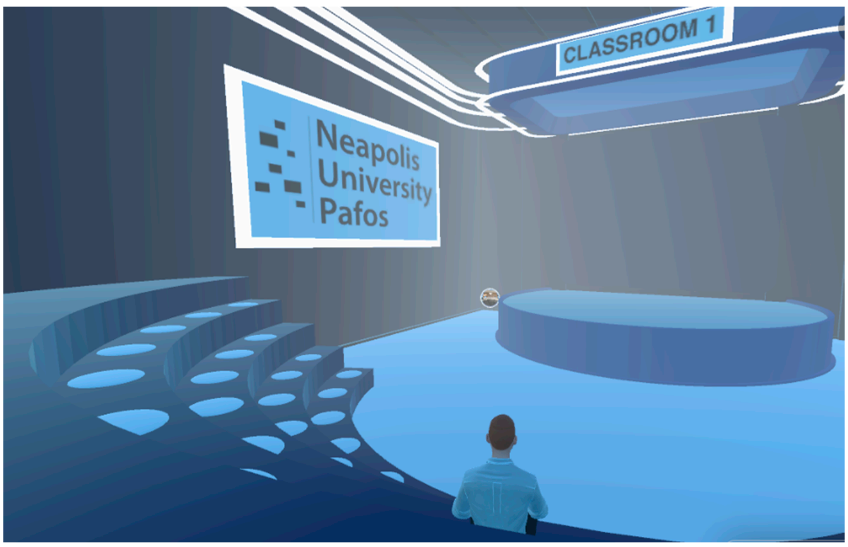

Figure 4. The metaverse classroom testbed.

This examination aims to validate the proposed framework model, linking educational features with learning metrics and evaluating the dynamic and interactive environment created on Spatial.io. Anticipated findings are expected to provide robust empirical evidence on the effectiveness of metaverse-based education, contributing significantly to advancing digital learning spaces by offering insights for optimizing virtual classrooms for enhanced engagement and academic success, thereby underlining the transformative potential of metaverse technologies in education.

4. Discussion

The proposed structural model introduces a novel approach for evaluating academic avatar performances within the educational metaverse. The integration of theories such as the Theory of Planned Behavior (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), and Community of Inquiry Framework (CoI) within the proposed model elucidates the complex interrelationships among key constructs like user engagement, technological adaptability, and educational efficacy. The findings substantiate the hypothesis of a positive correlation between technological adaptability and user engagement, underscoring the importance of user-friendly and adaptable educational technologies in enhancing avatar-mediated learning experiences. Additionally, the analysis corroborates the notion that the metaverse's immersive and interactive features significantly impact educational efficacy, affirming their essential role in augmenting the learning process. The development of a structural model in this study marks a significant advancement in formulating comprehensive assessment tools for educational contexts within the metaverse. This model goes beyond conventional educational assessment methodologies by capturing the nuanced dynamics of interaction and engagement in virtual environments, aspects often overlooked by traditional methods. The structural model proposed herein successfully integrates these vital dimensions, offering a more encompassing view of learning processes within the metaverse, but of course, it remains to be tested in an actual real learning environment.

In drawing connections to the literature review, this study aligns with the identified need for innovative performance appraisal models in virtual environments, as discussed by the authors [15,16]. This research resonates with the growing trend toward digital integration in education and performance management, indicating a shift toward more innovative, flexible, and inclusive approaches in educational and professional settings. This trend was exemplified in the study by Hedrick et al. [23], which evaluated the effectiveness of VR platforms like Meta Horizon Workrooms for immersive classroom experiences. The findings of this study have significant implications beyond the specific context of the metaverse. They contribute to a broader understanding of digital education landscapes, suggesting the need for educational strategies that are not only technologically advanced, but also pedagogically adaptable. As a result, this paper highlights the importance for educators and curriculum designers to adeptly integrate the dynamic aspects of the metaverse into their instructional methodologies, thereby catering to the continuously evolving demands of digital education.

Given the rapid evolution of technology in the metaverse and dynamic user behavior, future research should prioritize longitudinal studies to examine the adaptability and scalability of the proposed structural model over time. Empirical validation across diverse educational settings is essential for understanding the model's effectiveness comprehensively. Moreover, interdisciplinary approaches that merge educational technology with fields such as psychology, sociology, and data analytics could extend the research, fostering investigations into personalized learning experiences, adaptive educational systems, and artificial intelligence (AI) integration for performance tracking and feedback. Exploring the effects of virtual reality (VR) on various learning styles and gamified learning environments' effectiveness will offer valuable insights. Addressing privacy, security, and ethical issues in metaverse education is crucial for responsible virtual environment management.

To meet diverse learner needs, enhancing the model with adaptive learning paths that accommodate individual preferences and accessibility requirements is important. Utilizing AI and machine learning (ML) algorithms could allow for the dynamic adaptation of instructional content and assessment strategies for different learning profiles, including visual, auditory, and kinesthetic learners. Inclusive content creation strategies might utilize collaborative tools from companies like Google or Microsoft, enabling educators and students of various cultural backgrounds to co-create culturally sensitive learning materials that incorporate multiple perspectives, such as case studies from different regions and diverse representation in multimedia resources, making learning more inclusive and relatable.

5. Future Research Directions

Building on the established theoretical foundation, future research endeavors will aim to empirically validate the proposed performance evaluation framework structural model for the educational metaverse. This empirical validation is crucial for operationalizing the key theoretical constructs through advanced statistical methodologies, with a focus on Structural Equation Modeling (SEM). The integration of SEM is indispensable, facilitating the examination of complex interdependencies among variables such as user engagement, learning outcomes, metaverse tool utilization, and their collective impact on educational efficacy within the metaverse.

The framework will be deployed in controlled virtual learning settings using the Spatial platform within Neapolis University Pafos (NUP). This phase allows for the direct observation and collection of rich data reflecting student engagement, interaction patterns, and academic performance within a metaverse classroom. Guided by Key Performance Indicators (KPIs) defined in the theoretical framework, the data collection will concentrate on user engagement, tool utilization, and learning outcomes. Methods include surveys, direct observations, and the analysis of interaction data within metaverse platforms. A comprehensive questionnaire, designed to explore various aspects of the educational metaverse, will play a crucial role. This questionnaire assesses anxiety levels, the gamification experience, ease of use, perceived usefulness, skill and competence acquisition, knowledge acquisition, overall performance, and satisfaction within the metaverse environment. After immersive exploration, an in-depth analysis using SEM will be undertaken. This performance evaluation aims to quantitatively evaluate the metaverse's role in enhancing the educational experience by elucidating the relationships between theoretical constructs and observed outcomes. Validating the framework's applicability and uncovering insights to refine educational methodologies within the metaverse are essential steps. These steps are critical in providing empirical support for the proposed model.

Empirical validation is expected to offer substantial contributions to digital education research by providing nuanced insights into how virtual learning environments within the metaverse can optimize educational outcomes and student engagement. Based on empirical findings, especially those gathered through the questionnaire, the study aims to refine the performance evaluation framework, thereby enhancing its relevance, applicability, and effectiveness in diverse educational contexts. Moreover, insights obtained will offer valuable guidance for integrating dynamic aspects of the metaverse into instructional methodologies, addressing the evolving demands of digital education.

6. Conclusions

The exploration of the metaverse's educational applications through the proposed structural causal model is opening new avenues for pedagogical innovation and sheds transformative light on Human Resource Management (HRM) practices. Applying theories such as the Theory of Planned Behavior (TPB), the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Community of Inquiry Framework (CoI) to virtual environments, this study introduced a novel approach for assessing performance management in modern workplaces. The identified Key Performance Indicators (KPIs) align with traditional HRM metrics, highlighting the potential to adapt these indicators to virtual settings where avatars represent employees. This research underscores the ability to measure foundational HRM elements—employee engagement, tool utilization efficacy, and adaptability in digital ecosystems. The proposed model suggests reshaping HRM strategies for recruiting, training, and evaluating personnel within virtual environments, with relevance to educational settings and implications for enhancing remote work, virtual collaboration, and digital tool integration in terms of workforce productivity and satisfaction.

As the global workforce increasingly adopts remote and virtual working arrangements, avatar performance insights become crucial. Avatars, representing employees in the metaverse, can yield valuable data on performance management, employee engagement, and training effectiveness. This perspective is vital for HRM professionals navigating workplace digitalization challenges and opportunities. This study highlights the metaverse's role in evolving traditional HRM practices, emphasizing the growing importance of managing and evaluating performances in virtual spaces.

Therefore, this paper contributes to a new understanding of performance management that transcends physical confines, utilizing virtual platforms for a dynamic and holistic workforce assessment. By analyzing key performance indicators, educators can identify areas for improvement and tailor teaching methods accordingly. Moreover, this research emphasizes the importance of the adaptability, engagement, and effective use of metaverse tools in enhancing the learning experience. Educational practitioners can apply these principles to design and deliver more engaging and adaptable virtual learning experiences. For example, they can use the insights from this study to create customized learning paths for students based on their performance and engagement levels, ultimately leading to a more personalized and effective educational practice. Lastly, this paper's KPIs provide educators with specific metrics with which to evaluate and improve the effectiveness of virtual learning environments. For instance, by monitoring "Metaverse Tool Utilization", educators can identify which tools are most effective for enhancing student engagement and then adjust their teaching strategies accordingly.

To conclude, the proposed model may contribute to the advancement of new technology educational methodologies within the metaverse and promote innovative educational and HRM practices for the digital economy era. By clarifying the links to performance and individual satisfaction, the model could act as a basis for educators and HR professionals to adapt their strategies to leverage virtual environments for human capital management and development.

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