Meta-Education: A Case Study in Academic Events in the Metaverse

Rodrigo Meliande[2], **Ailton Ribeiro**[1], **Murilo Guerreiro Arouca**[1]
Ana Maria Amorim[3], **Maria Clara Pestana**[1], **Vaninha Vieira**[3]

[1]Programa de Pós-Graduação em Ciência da Computação, UFBA

[2]Bacharelado em Ciência da Computação, UFBA

[3]Instituto de Computação, Universidade Federal da Bahia, UFBA

{rodrigo.meliande, ailton.ribeiro, murilo.guerreiro}@ufba.br

{ana.amorim, mpestana, vaninha}@ufba.br

Abstract. *The metaverse, which encompasses virtual universes beyond our reality, promotes interactions that surpass the limitations of conventional online communication technologies, such as the lack of presence and representation. Due to the evolving nature of the metaverse, research related to its application in education is limited, especially regarding the organization of events in this context. Thus, the methodology of this research includes a case study in an academic workshop consisting of tool analysis, virtual environment implementation, and participant evaluation. The results aim to broaden the understanding of the educational potential of the metaverse and stimulate future research in meta-education.*

1. Introduction

The Metaverse constitutes an extension of the internet that transfigures our conventional two-dimensional (2D) encounter into an interactive three-dimensional (3D) virtual realm. This intricate environment finds support in cutting-edge technologies, encompassing virtual reality (VR), augmented reality (AR), artificial intelligence (AI), blockchain, Internet of Things (IoT), and human-computer interface (HCI) [Barry et al. 2015, Lee et al. 2021, Erol et al. 2023]. Coexisting with the tangible world, the Metaverse serves to facilitate our routine online engagements [Dwivedi et al. 2022]. While the gaming domain has historically spearheaded the integration of AR/VR technologies, as exemplified by the triumph of Pokémon Go[1], the scope of the Metaverse extends beyond gaming, encompassing diverse spheres such as healthcare [Lemos 2022, Zhang et al. 2022], collaborative endeavors, and educational pedagogy [de Classe and de Castro 2023a, Song et al. 2023, Ho et al. 2023].

Within the educational context, various institutions are strategically embracing methodologies entailing the development and utilization of online resources [Duan et al. 2021, Nagao 2023, Alvarez et al. 2023]. Amid the backdrop of the COVID-19 pandemic[2], conventional communication platforms like Google Meet[3] gained

[1]Available at: https://pokemongolive.com/. Accessed on: January 20, 2024.
[2]Available at:https://www.paho.org/pt/covid19. Accessed on: January 20, 2024.
[3]Available at:https://meet.google.com/. Accessed on: January 20, 2024.

widespread employment and underwent progressive evolution, incorporating features such as personalized backgrounds and 3D avatars. Concurrently, emerging tools tailored to explore the potentials of immersive worlds garnered prominence, exemplified by platforms like VRChat[4], Spatial.io[5], Mozilla Hubs[6], among others.

The growing demand for educational environments in the Metaverse has given rise to the concept of meta-education, representing a form of education that transcends conventional methods [Mystakidis 2022]. While ongoing debates surround the benefits and challenges of the Metaverse in education [Tlili et al. 2022], some works are investing in the development and delivery of content in this environment. Frameworks such as those proposed by [Wang et al. 2022a] are shaping the guidelines for future educational systems. Due to the constantly evolving nature of the Metaverse, there remains a significant gap in research related to its application in education, especially concerning its diverse uses by different audiences and in various collaborative academic contexts.

The path toward an academic environment adapted to the Metaverse presents significant challenges, including the need for accessible 3D resources, comprehensive considerations of inclusivity, financial viability, privacy security, and access to suitable technological resources and services. These elements play a crucial role in the pursuit of widespread and successful adoption of the Metaverse in the educational landscape. Thus, this study aims to contribute to the understanding and advancement of this ever-evolving field.

The main objective of this work is to explore the concepts of the metaverse from an educational perspective and develop an environment that can facilitate academic activities in the metaverse, allowing us to assess participants' experiences. To achieve this general goal, we have defined specific objectives as follows: i) Understand the fundamental concepts of the metaverse and meta-education; ii) Identify challenges associated with the current method of remote teaching and highlight how the metaverse can contribute to addressing these challenges; iii) Identify and select tools that can assist in the development of environments for conducting academic activities, and; iv) Build an environment for a case study that enables the execution of academic events within the metaverse and evaluate the participants' experiences in a real-world scenario.

The subsequent sections of the manuscript are organized as follows. Section 2 delineates the background and related works, encompassing the foundational concepts of the metaverse and meta-education. Section 3 explicates the employed methodology. Section 4 details the tool analysis. Section 5 presents the case study. Section 6, results. Section 7, discussion. Section 8, limitations. Finally, Section 9 conclusion and future work.

2. Background and Related Works

We identified basic concepts through literature research related to "Metaverse and Education". This section presents these concepts and discusses related works.

[4]Available at:`https://hello.vrchat.com/`. Accessed on: January 20, 2024.
[5]Available at:`https://www.spatial.io/`. Accessed on: January 20, 2024.
[6]Available at:`https://hubs.mozilla.com/`. Accessed on: January 20, 2024.

2.1. Metaverse and Avatars

We have witnessed the transformation of the technology and social media giant, Facebook, into Meta Platforms[7], referencing the emerging concept of the Metaverse. This signals the growing market trend towards investments in this new segment. The first use of this concept, as we have it today, is attributed to Neal Stephenson's book Snow Crash, published in 1992 [Suh and Ahn 2022].

In the metaverse, users can interact with each other and with virtual objects in a shared three-dimensional space through two approaches: the technological and the ecosystem. This is the definition provided by [Lee et al. 2021] used as a reference in this work. The technological approach encompasses various modes of access to the metaverse, including the concept of Extended Reality (ER), which includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). Each of these modes requires different electronic devices to enable interaction in the metaverse, resulting in varying levels of immersion. Simultaneously, the metaverse ecosystem includes all the fundamental elements that enable its existence and operation. This includes virtual assets, avatars, virtual economy, and ethical considerations, among other aspects, as highlighted by [Mystakidis 2022].

Avatars play a central role in the metaverse, standing out as the primary means of interaction and user identification. Their presence is crucial for building a sense of active participation in the virtual environment, thus playing a crucial role [Nowak and Fox 2018, Ribeiro 2021].

2.2. Meta-education

The integration of the metaverse concept and innovative technologies presents opportunities for a novel paradigm education referred to as meta-education [Mystakidis 2022]. This approach holds the potential to deliver immersive experiences within 3D virtual environments, fostering a sense of presence through the representation of users as avatars [De Felice et al. 2023].

Traditional platforms like Moodle[8] are widely used to support learning in a virtual environment but offer limited interaction options [QUANSAH and Essiam 2021]. On the other hand, Gather.Town[9], a web-based 2D platform that emerged during the pandemic, provided increased interaction among users compared to traditional environments, although it still has limitations in the sense of presence. Other alternatives include Second Life[10] and Virbela[11], used by universities for virtual events and remote collaboration. Additionally, Roblox[12] has been explored for teaching programming knowledge [Han et al. 2023]. There are also web-based options, such as Mozilla Hubs and Spatial.io, each with its features, but these may have limitations and restrictions for free use.

[7] Available at:`https://about.meta.com/`. Accessed on: January 20, 2024.
[8] Available at:`https://moodle.com/pt-br/`. Accessed on: January 20, 2024.
[9] Available at:`https://pt-br.gather.town/`. Accessed on: January 20, 2024.
[10] Available at:`https://secondlife.com/`. Accessed on: January 20, 2024.
[11] Available at:`https://www.virbela.com/`. Accessed on: January 20, 2024.
[12] Available at:`https://www.roblox.com/`. Accessed on: January 20, 2024.

2.3. Related Works

Table 1 addresses proposals similar to this work; all of them investigated various metaverse platforms in the context of education to understand their impacts. In their research, [de Classe and de Castro 2023b] utilized the 2D platform Gather.Town to create a virtual classroom, where they conducted coordinated activities that encouraged collaboration and cooperation among students. As a result, it was possible to observe indications that the use of the metaverse as a hybrid learning environment was perceived by students as positive in terms of collaborative support and learning, resulting in a strong correlation between these two aspects.

Table 1. Related works

Works	Platform used	Type of activity
[de Classe and de Castro 2023b]	Gather.Town	Virtual classroom
[Wang et al. 2022b]	Virbela	Virtual college campuses
[Barry et al. 2015]	Second Life	Virtual college campuses
This work	Spatial.io	Academic events: Workshop

Similarly, [Wang et al. 2022b] and [Barry et al. 2015] developed virtual university campuses using the 3D platforms Virbela and Second Life, respectively. The work by [Wang et al. 2022b] introduced the concept of "metaversity", a combination of the terms "metaverse" and "university", suggesting the construction of increasingly realistic virtual campuses. The authors investigate how this approach can enhance learning and community collaboration, analyzing various activities conducted in the virtual environment, such as guided tours and conferences. However, they do not provide details about the participant audience and do not address the assessment of satisfaction with the use of these activities.

In the study conducted by [Barry et al. 2015], the authors investigated students' learning behavior in a metaverse environment. To achieve this, researchers adopted an approach that involved the use of an eye-tracking system, allowing for the analysis of students' interactions and reactions to stimuli in the virtual environment. The results of this work provide insights into the dynamics of learning in metaverse environments.

In the context of this study, we utilized the 3D Spatial.io platform as the setting for conducting an academic event, specifically a workshop. We assessed participants' experiences using the 3C collaboration methodology [Fuks et al. 2008]. It is worth noting that our research stands out due to the choice of this platform, which offers advantages compared to those used in previous studies, as outlined in Table 2.

3. Methodology

The adopted methodology consists of four main steps, as shown in Figure 1. In the exploratory study, we sought theoretical references that underpinned the formulation of the proposal for the investigated problem. This process also laid the essential foundation for the modeling and development of the test environment within the metaverse context. We chose to adopt the 3C Collaboration Method as an approach to enhance the effectiveness of using virtual environments in academic contexts. According to [Fuks et al. 2008], the interaction between communication, coordination, and cooperation can significantly enhance the perception of the learning process in virtual systems.

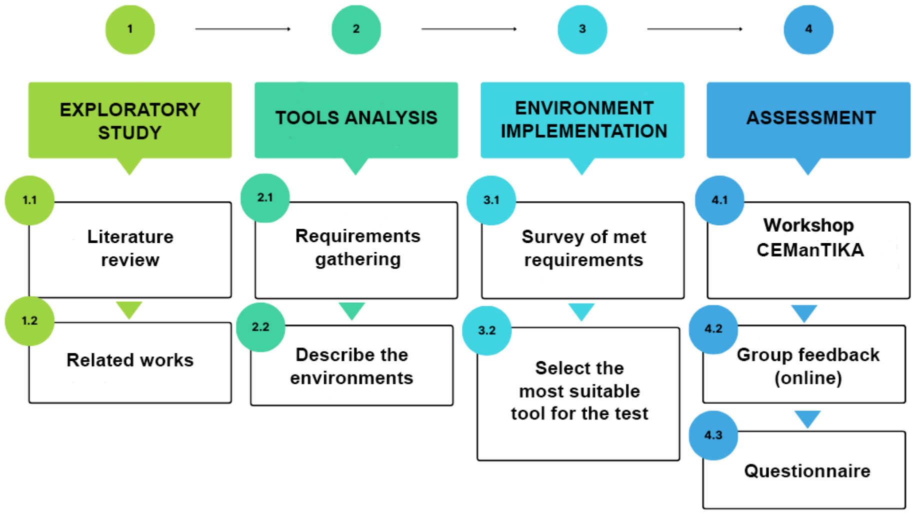

Figure 1. Methodology diagram.

During the analysis of tools, we identified the minimum and desirable requirements for conducting an academic event in a metaverse environment. The chosen type of online activity was an academic workshop. The defined minimum criteria included the ability to communicate through voice, video, and multimedia resource sharing. As for the desirable requirements, they encompassed the presence of avatars, spatial audio, and the ability to create audio subdivisions to facilitate specific discussions. During the implementation phase of the environment, after selecting the platform that best met the established requirements, we developed a comprehensive plan for all activities related to the academic event. This included the creation of a detailed schedule, the selection, and invitation of speakers, as well as the execution of necessary promotional strategies, and the establishment of the required environments for conducting activities in the metaverse.

In the process of evaluating participants' experiences, we conducted a research workshop in a metaverse environment at a federal university. The assessment occurred in two main stages: immediate feedback collection after the workshop and an online questionnaire following the event. The questionnaire, based on Palloff's findings [Palloff and Pratt 2010] on learning in virtual environments, addressed participants' profiles and assessed their knowledge of the metaverse, as well as their experiences during the workshop. The complete questionnaire is available online[13].

4. Tool Analysis

Table 2 presents a synthesis of the main characteristics that were evaluated in the tools subjected to testing, namely Spatial.io, Roblox, MozillaHubs, Second Life, and Virbela. These tools were previously identified by [Wu et al. 2023] as having the potential to support the creation of learning environments within the metaverse context.

Among the minimum requirements defined for evaluation, including the ability to easily share multimedia and the availability of voice and video communication means, with quality comparable to or better than those offered by conventional video conferencing tools such as Google Meet or Zoom. Another crucial element to facilitate effective

[13](Questionnaire available at URL). Accessed on: January 20, 2024.

interaction and communication in metaverse environments is the presence of customizable avatars and the flexibility to personalize environments according to different activities of varied nature. Additionally, features such as spatial audio and the ability to create audio subgroups play a fundamental role in creating an immersive experience and replicating real-world situations. For instance, spatial audio allows a user's voice to be heard only by nearby participants, with the volume adjusted based on the distance between avatars.

Table 2. Analysis of 3D tools based on their characteristics and requirements.

Characteristics	Spatial.io	Roblox	MozillaHubs	Second Life	Virbela
Voice Communication	✓	✓	✓	✓	✓
Video Communication	✓	✗	✓	✓	✗
Screen Sharing	✓	✗	✓	✗	✗
Customizable Avatars	✓	✓	✓	✓	Limited
Customizable Environments	✓	✓	Limited	Limited	✓
Spatial Audio	✓	✓	✓	✓	✓
Audio Subgroups	✓	✓	✓	✓	✓
Free	✓	✓	✗	✓	✓
Open-source	✗	✗	✗	✗	✗
Interoperability	✓	✗	✗	✗	✗
Hardware Independence	✓	✗	✓	✓	✗

In addition to these criteria, the tool analysis encompassed the availability of free options and consideration of whether the tools were open-source. Additionally, other relevant features were considered in the evaluated solutions, such as interoperability (i.e., the ability to use the same avatars and resources across different metaverse platforms) and hardware independence, ensuring that tools could be accessed with minimal equipment and processing power requirements. This comparative analysis served as the foundation for selecting the tool to be used for the academic workshop within the metaverse.

5. Case Study: Academic Workshop in the Metaverse

This section describes a case study conducted at an academic workshop within the Metaverse using the Spatial.io platform.

5.1. Tool Selection: Spatial.io

We chose to use the Spatial.io tool due to its ability to meet both essential and desirable requirements, offering functionalities comparable to traditional platforms such as video and voice communication, as well as screen sharing. This tool provides options with both a free and premium version. One of the advantages of the tool is the ability to customize avatars, along with the flexibility to customize environments with features like multifunctional media boards and decorative 3D models. Additionally, its accessibility across various devices, including smartphones and computers, along with the availability of free applications, significantly expanded its reach and availability. The tool integrates with ReadyPlayerMe[14], an open-source platform, ensuring interoperability, allowing the same avatar to be used in different virtual contexts. It's worth noting that while the choice of the Spatial.io tool has proven to be suitable, it's important to highlight that none of the tools analyzed in the study are open-source.

[14]Available at:https://readyplayer.me/pt-BR. Accessed on: January 20, 2024.

5.2. Implementation of the Environment

The initial process for designing the workshop involved creating its schedule, which comprised a series of activities. The schedule commenced with a panel discussion on experiences at national and international scientific events, followed by a lecture covering the topic of Experimental Software Engineering. After the lecture, a 15-minute break was scheduled, during which participants could explore the environments and the platform used. This break was followed by the technical session of the group, which included a preview of a thesis defense from one of the students. Additionally, we developed a dedicated website for the event[15], where we provided pertinent information such as registration details, the schedule, promotional banners, and detailed instructions to access the platform, which included an option for participants to have a preliminary orientation.

To facilitate participation and offer effective support, we provided instructions alongside the registration on how to access the platform. Links to support groups on WhatsApp and Discord were made available for real-time assistance. To simulate in-person events, we created diverse environments such as presentation rooms, galleries for displaying works, and social areas (e.g., coffee breaks). During the break, participants explored various communication tools within the platform, including avatar reactions, voice communication, chat, and video.

To enhance participant mobility within the environment and facilitate access to the created scenarios, we incorporated rapid teleportation portals. These portals are features of the platform that enable instant transportation of participants between various event environments, as illustrated in Figure 2. They can be created in real-time to make the experience more interactive or positioned at strategic locations for convenience. Additionally, a central space served as the entry point to other event environments, presenting an image gallery with brief descriptions of the showcased works to participants.

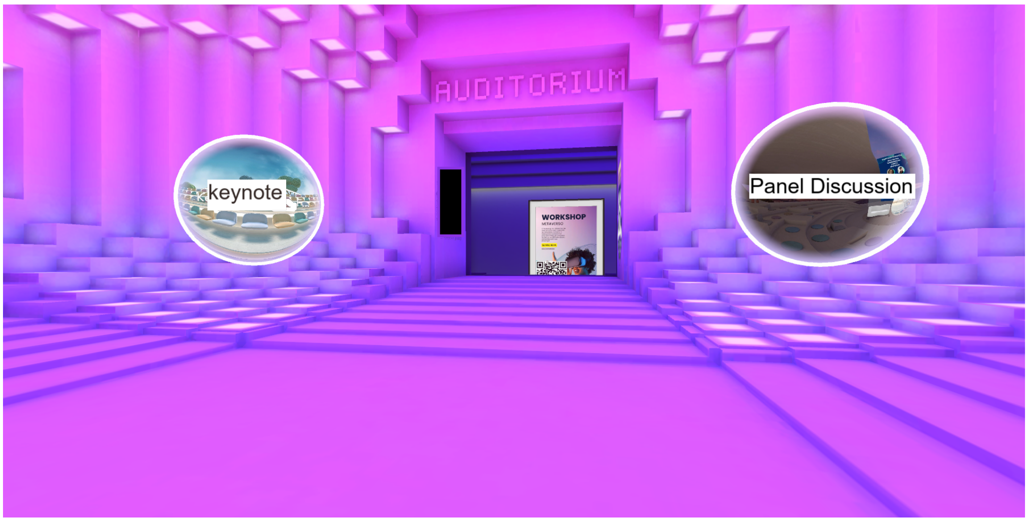

Figure 2. The screenshot shows two portals at the auditorium entrance for quick transportation of participants between different event environments.

[15] Available at https://workshop-cemantika.vercel.app/. Accessed on January 20, 2024

5.3. Execution of the Workshop

The workshop took place in June 2023 and had nine registered participants. The event unfolded according to the scheduled program, commencing at 9:00 AM with an orientation session where participants had the opportunity to take a guided tour of the environment to familiarize themselves with it. Subsequently, at 9:20 AM, a panel discussion began where participants shared their experiences at both national and international events. Throughout this interaction, participants responded to audience questions using both the chat and audio communication.

Figure 3 displays a screenshot of the environment during the roundtable discussion, where participants' avatars are positioned in their respective places. Speakers occupied the sofas, while listeners freely chose their spots within the environment. This space, with its cozy and reduced dimensions, was designed to simulate an authentic roundtable discussion, encouraging interaction and mutual observation among participants.

Figure 3. Screenshot taken during the panel discussion.

At 10:00 AM, the keynote presentation on Experimental Software Engineering by a guest speaker took place. Figure 4 shows a screenshot of the environment during the presentation. The space was designed as a spacious open-air auditorium, providing a panoramic view of the stage and participants. Viewers could control the zoom of the projected images to adjust slide legibility. Moreover, there was interaction allowing participants to ask questions and express reactions using avatars, such as applauding at the end of the presentation.

After the presentation, there was a break for social interaction among participants, allowing for informal conversations with the speaker and colleagues. Some activated cameras for a closer experience, while others explored different environments. The break aimed not only at interaction, but also at providing visual rest to mitigate screen fatigue. At 11:00 AM, a preview of an undergraduate thesis defense began, using the same environment as the previous presentation, but with a nighttime theme configuration to create a visual distinction in the environment's lighting. Figure 5 displays a screenshot of this moment.

Figure 4. Screenshot taken during the keynote presentation.

Figure 5. Screenshot taken during the preview of the undergraduate thesis defense.

The last activity of the workshop, held from 12:00 PM to 12:30 PM in the same environment as the Thesis Defense preview, comprised two distinct moments. Firstly, there was a collection of feedback from the participants through a group conversation where they could share their opinions, both positive and negative. Figure 6 illustrates a screenshot of this moment. Subsequently, the second segment was dedicated to providing instructions on filling out an online questionnaire aimed at capturing perceptions and evaluating participant satisfaction regarding their experience in the metaverse workshop.

6. Results

The questionnaire involved 9 participants. Considering age distribution: 2 participants were between 21 and 30 years old, 3 were between 31 and 40 years old, 2 were between 41

Figure 6. Screenshot taken with participants at the end of the event for feedback collection.

and 50 years old, and 1 participant was over 50 years old. Regarding gender, participants had the option to choose a gender that best represented them, and it was possible not to define themselves within the proposed male and female categories. Of the 9 participants, 4 identified as female, while the remaining 5 identified as male. Regarding educational background, 2 were undergraduates, 4 were postgraduate students, and 3 held doctoral degrees.

Participants expressed a positive outlook on the potential benefits of integrating Metaverse environments into similar academic events. A large majority, 88.9%, believed that the Metaverse could offer more realistic simulations, and then 77.8% highlighted the ability to create customized environments for each subject. Furthermore, 66.7% recognized the importance of practical experiences provided by the Metaverse, followed by an appreciation for the effective use of multimedia resources, although 55.6% believed that the Metaverse could overcome limitations of traditional teaching methods in this aspect.

The importance of clear communication was emphasized by participants, with 66.7% highlighting it as a key element to enhance interaction between students and teachers. Additionally, 55.6% of participants pointed to screen sharing, multimedia resources, and avatar reactions with emojis as relevant factors. Voice communication was mentioned by only 33.3% of participants. Some noted that avatars provided a sense of immersion and facilitated contact, while others highlighted the effectiveness of communication through simulations in virtual environments. It's important to note that one evaluator emphasized the need for enhancements, as not all aspects could be evaluated. Regarding the improvement of cooperation between students and teachers, 44.4% of participants saw significant potential, 33.3% remained neutral, and the remaining 22.2% were divided between slightly low and high potential for improvement.

Regarding avatar representation, 44.4% felt well-represented, while 55.6% expressed reservations about the avatars' ability to represent all participants. Compared to traditional video conferencing environments, 77.8% rated the experience as significantly better. Voice communication was positively evaluated by all, but video communication functionality was not assessed, as not all participants had built-in cameras or simply chose not to use them. The majority of participants welcomed avatar reactions, although some did not express an opinion or did not consider this feature positive. All participants had a positive view of the use of avatars, with varied assessments for multimedia and scenarios, including some reservations. Participants expressed interest in engaging in future events like this in the metaverse, presenting an opportunity for in-depth studies to address potential challenges.

7. Discussion

Based on participants' perceptions, we identified key points in the workshop experience conducted in the modeled Metaverse environment. These points include: reduced fatigue, increased concentration, a sense of closeness, preference over traditional tools, appeal to innovation, benefits of limited space, and considerations regarding the size of the environment.

There were reports of a reduced sense of fatigue after almost 4 hours of the event compared to the use of traditional communication tools. The fact that participants reported less fatigue compared to traditional communication tools is considered a positive outcome. This suggests that the Metaverse may provide a more engaging and less exhausting experience during similar academic events. This finding is relevant, especially in a context where virtual fatigue has become a growing concern due to the extensive use of video conferencing tools. Some participants noted an increase in concentration and focus during the event compared to traditional video conferencing technologies. The observation of an increase in participants' concentration and focus is intriguing. This may indicate that the visual stimuli provided by avatars and the virtual environment of the Metaverse can keep participants more engaged and attentive during the event.

The illusion of proximity among participants was frequently mentioned as a positive aspect that contributed to effective communication and participant interest. The illusion of proximity is a notable aspect, as it can help enhance communication and participant engagement. In an educational context, feeling close to fellow participants and speakers can contribute to a richer learning and discussion experience. The tool itself facilitates the emulation of these subtle interactions during a session, enabling participants to, for instance, engage in conversations with peers seated nearby even during a formal presentation. Despite some reservations, the experience in the Metaverse was considered more engaging than the use of traditional virtual communication tools.

The observation that Metaverse environments did not dare enough and needed innovation is a valid point. Creative and unconventional approaches are necessary to fully harness the potential of the Metaverse, going beyond simple replication of the real world. The smaller space of the discussion circle was well-received for facilitating interactions among participants and enabling clearer discussions. Thus, the importance of careful design of virtual environments is emphasized. Smaller spaces can promote more meaningful interactions and facilitate effective communication. There were criticisms regarding the size of the lecture environment and the preview of the undergraduate thesis defense, suggesting that this may have hindered the visualization of multimedia materials. The criticisms about the size of certain environments suggest that the optimization of virtual space is crucial.

The Metaverse also faces ethical and security challenges, including privacy, data security, content moderation, and harassment prevention, requiring careful considerations to create a safe and positive learning environment [Lee et al. 2021]. In addition to the mentioned challenges, physical and mental health requires careful assessment. This includes the impact of frequent use of equipment and multisensory stimuli on the physical and psychological health of users. These participant observations provide important insights into the Metaverse experience and point towards potential improvements and directions. It is crucial to note that challenges related to inequality in global internet access also become evident in this context. Such challenges encompass not only technological issues but also social and cultural considerations.

8. Limitation

It's crucial to acknowledge some limitations. Firstly, the study did not assess the impact of certain features, like real-time translation and live subtitles, on user collaboration and communication. Additionally, long-term studies, especially focusing on the physical and mental well-being of users with recurrent use of metaverse environments, are necessary. The study primarily replicated real-world environments, limiting exploration of the broader possibilities offered by the virtual universe. The number of participants is also a limitation. Lastly, the assessment did not extend to other types of longer-duration events, such as symposiums and conferences.

9. Conclusion and Future Work

This study focused on the application of Metaverse environments in the academic context, involving an analysis of Metaverse concepts and Meta-education, as well as the creation and evaluation of a virtual metaverse environment. The application of the 3C model in our research involved integrating its principles to assess and optimize communication channels, coordination mechanisms, and cooperative dynamics within Metaverse environments. This contributed to a nuanced understanding of collaborative intricacies, enhancing the overall validity of our research outcomes. The research contributes to the understanding and practical application of the Metaverse in the educational context, offering insights that can inform future developments and improvements in this evolving field.

This research lays the groundwork for future investigations. Firstly, there is a need to explore strategies ensuring accessibility and inclusion in the Metaverse, making these environments fully beneficial for all students, including those with disabilities. A longitudinal study could track how participants' perceptions evolve in academic Metaverse environments, especially with higher participant numbers. This would deepen our understanding of the long-term impacts. Furthermore, expanding research to explore Metaverse applications in diverse academic contexts, including traditional classrooms, is also pertinent.

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