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Article

Enhanced inclusion and accessibility in education and training through virtual worlds

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Abstract: Based on the evolution of immersive technologies, both in software and hardware, this article proposes a methodology for creating accessible and inclusive virtual worlds, with potential impacts on education, training, and lifelong learning. Through this paradigm, the combination of real and virtual cosmos generates new challenges in accessibility and inclusion. The co-existence of virtuality in tangible real life could be extended respectively in a wide spectrum of everyday life for enhanced inclusion and accessibility. New business models and even more accessible services in training and education could be raised through this suggestion. Metaverse, omniverse, and the advancements in extended reality equipment are the main allies in this endeavor. Artificial intelligence and enhanced experiences via advanced immersion could find easily their role in the context of meaningful virtual worlds in lifelong learning. As we are in the dove of the Metaverse era this is a unique opportunity to build accessible and inclusive virtual worlds from the very beginning.

Keywords: virtual worlds; metaverse; inclusion; accessibility; education; training; lifelong learning

1. Introduction

In recent years, the discussion about the Metaverse and its potential architecture has opened [1–4]. The core idea is the sharing of significant parts of everyday life in immersive digital spaces [3]. The Meta company has announced the execution of a $50 million investment in global research and program partners to ensure Metaverse's products will be developed responsibly [5]. Nvidia proposed the Omniverse, which is a real-time collaboration platform that is based on three-dimensional (3D) graphics [6]. The European Commission adopted the terminology of virtual worlds that are persistent, immersive environments, based on technologies including 3D and extended reality, which make it possible to blend physical and digital worlds in real-time, for a variety of purposes such as designing, making simulations, collaborating, learning, socializing, carrying out transactions or providing entertainment [7]. According to the European Commission, the global market size of virtual worlds is estimated to grow from €27 billion in 2022 to over €800 billion by 2030 [8].

With the assistance of democratized game engines such as Unity3D [9], Unreal [10], and more, developers are experimenting with new opportunities for sophisticated extended reality devices and applications [11–13]. In addition, the possibility to include characteristics from emerging technologies, such as haptics [14–19] and sensors [20–23], as well as the achievements from the sector of artificial intelligence

(AI), maximizes the user's expectations [24–30]. Furthermore, predefined virtual world platforms can be customized and adapted to the needs of users to develop specialized virtual worlds, such as for the needs of conferences or trade shows [2,31]. At the same time, users can subscribe to services offered by pre-existing virtual worlds, as an extension of new and social media into the realm of the Metaverse [2,32,33]. An important ally in the expansion and adoption of virtual worlds by the general public is both the existing Web 3.0 and its evolution into Web 4.0 [4,7,8,34]. In particular, the evolution of Web X.0 will be able to support the ever-increasing demands of users and systems, regarding the uninterrupted and near-zero latency transfer of data and information [2,4].

Virtual worlds and the Metaverse are expected to be applied to all aspects of everyday life [35–37]. Preliminary and extensive analyses of the needs and requirements that virtual worlds should address have been proposed in recent years [38–43]. As they are in their early stages of development, it is the appropriate time to deeply explore the opportunities and analyze needs that exist so that virtual worlds are designed and developed with inherent accessibility and enhanced inclusion [44–47]. In particular, virtual worlds are expected to coexist and interact with real-life [3,44]. If the Metaverse is being developed without restrictions or limitations on access to infrastructure, services, and information, as well as without exclusion and discrimination of any kind, then it could also contribute, to enhancing accessibility and inclusion in real-life [3,41,44]. Therefore, it is imperative to set the human at the center of the design and development of virtual worlds, through extensive and in-depth collaboration of interdisciplinary research fields.

Further research is required to ensure that the Metaverse and virtual worlds will be accessible and inclusive by placing humans in the loop. This study attempts to shed more light on the accessibility and inclusion of virtual worlds from their design phase in training and education. This research aims to contribute to the ongoing debate regarding the deeper analysis of the interaction between virtual worlds and real-life in learning, training, and educating. Section 2 presents the main pillars of this research and introduces a methodology for enhanced accessibility and inclusion in virtual worlds of training and education. Section 3 analyzes an indicative use case in training and education and depicts the application of accessibility and inclusion by design. Section 4 provides a discussion place for human-centered virtual worlds, while Section 5 concludes with the main outputs of this research.

2. Materials and methods

2.1. Research questions

The scope of this research is to explore further the factors and ways in which virtual worlds and the Metaverse could ensure greater accessibility and inclusion from the design phase in training and education. In particular, the research questions (RQs) that will be explored to achieve this goal are the following:

RQ1: What factors determine the degree of accessibility and inclusion in the virtual worlds of the Metaverse in Training and Education?

RQ2: What are the characteristics of the creative industries of video games and

how could they contribute to enhanced accessibility and inclusion in virtual worlds of Training and Education?

RQ3: How could immersive technologies contribute to developing accessible and inclusive virtual worlds in Training and Education?

RQ4: How could emerging technologies enhance accessibility and inclusion in virtual worlds in Training and Education?

To address RQ1, we are examining the users' involvement in the preproduction phase of virtual worlds. Regarding RQ2, RQ3, and RQ4 we examine a use case of virtual worlds from the domain of training and education. The exploration of the use case is based on the following structure. Initially, we depict the challenge. As the second step, we describe a perspective of the case study in education and training. Finally, we focus on the enhancement of accessibility and inclusion for the case study.

2.2. Methodology for creating inclusive and accessible virtual worlds

Metaverse and virtual worlds should be spaces of equal participation and collaboration, where inclusion without any socio-economic limitation, and accessibility free of kinesthetic limitations will be among their key components [33,44]. In this sense, formulating and implementing guidelines, rules, and standards at all stages of the life of virtual worlds would be a way to ensure universal accessibility and equal inclusion in the Metaverse. In a broader sense, the involvement of all stakeholders in the co-design, co-development, evaluation, and validation, as well as in the use of virtual worlds would ensure the maximum degree of enhanced accessibility and equal inclusion in the Metaverse. On the one hand, the interdisciplinary contribution from heterogeneous fields is imperative for the success of this endeavor. On the other hand, the technological progress made in both immersive and emerging technologies could be an ally for improved accessibility and inclusion in virtual worlds. Thus, special attention should be paid to the factors that determine accessibility and inclusion in the Metaverse and virtual worlds, as well as to the horizontal monitoring of the implementation of guidelines and standards throughout their life cycle. Education and training are representative fields where developing guidelines for enhanced accessible and inclusive virtual worlds could benefit socioeconomic life.

2.2.1. User needs and requirements

Metaverse and virtual worlds provide innovative services in education and training. Data and content are represented as information that users interact with. Thus, the analysis of user needs regarding: a) services, b) information, and c) interactions in virtual worlds, should focus on the user needs of a wide audience. During the phase of preproduction, accessibility and inclusion should be the factors that will be examined in depth. Virtual worlds should address any potential issue that could emerge as obstacles in the provided services or information or interaction with the users. Potential barriers to accessibility and inclusion in virtual worlds should be identified in kinesthetic reasons, problems of understanding and perceiving information, issues of access to services, and cases of usability, as well as in reasons of technophobia. Through interdisciplinarity, the needs and constraints should be taken from the end users of the learning sector. With various research tools and the assistance of experts

from different scientific fields, a substantial mapping and analysis of users' needs of the metaverse could be carried out (RQ1).

2.2.2. Co-design

Co-creation is a way to ensure the active participation of users in the co-design of virtual worlds for educational and training purposes. Adopting practices to actively involve users in the design of virtual world usage scenarios will enhance the degree of accessibility and inclusiveness of the Metaverse. Additionally, users could either contribute to the co-creation of the extended reality content or highlight specific needs that the generated content should meet. Also, the multimodality of information representation could be ensured by the active participation of end users during the pre-production phase. Ensuring that content is automatically adapted to each trainee's perceived language would be a factor, in enhancing inclusion in educational virtual worlds. Finally, ensuring that user interfaces serve all users, from diverse backgrounds, is an important factor for human-centered virtual worlds (RQ1).

2.2.3. Content in the Metaverse and virtual worlds

One of the components of the Metaverse and virtual worlds is 3D graphics. The 3D objects that will be placed in the virtual space could have a decorative or functional purpose [48]. 3D models can be produced from scratch by using dedicated software packages with digitization methods, such as photogrammetry or 3D scanning, or even with a mix of these techniques [49–53]. In recent years, the use of artificial intelligence has optimized the quality of the generated 3D objects, whereas, at the same time, it has decreased the time of this process [54,55]. When all these techniques are combined, the result could be more efficient, and of high quality. The more details in the 3D objects, the higher the level of photorealism, but also with more complexity [53]. The higher the level of photorealism, the more confidence of the users that they are in a realistic virtual space. In the case that the educational virtual worlds would be used offline, so the rendering is taking place on a local computational system, the user experience could be enhanced. Otherwise, the developers must proceed with optimizations, sacrificing the quality of the graphics, so that the user can have a smooth experience (RQ2).

The Metaverse and virtual worlds can be accessed with the help of World Wide Web connectivity. The higher the speed of the data transfer, the smoother and easier the user experience will be [2,4]. However, it is very important to focus on ensuring that all actors have equal and free access to virtual worlds and the Metaverse, without exclusions and barriers [44–47]. In this direction, the ongoing effort for enhanced accessibility and inclusion in the Metaverse, regarding the services offered, multi-layered, and multi-modal representation of information should be intensified (RQ1).

2.2.4. Immersive and emerging technologies in training and education

The ongoing rally in the field of extended reality equipment has impressive results and challenges. The simplification of the user controllers, even their complete elimination due to the integration of the detection of the movement of the user's hands, offers an even greater degree of immersion in virtual spaces. The user interacts in an almost natural way, while the detection of eye-tracking and the recording of facial expressions are captured in real-time in the virtual world [56–59] (RQ3). In some cases,

electroencephalograph devices are also used to capture and analyze the feelings of the users [60]. Haptic devices and haptic gloves try to enhance the immersion of the user, through the inclusion of the sense of touch in the virtual world [50]. Meanwhile, the sense of smell is at a low technological level, but it is expected to provide advanced immersive experiences shortly [61] (RQ4). For the cooperation of heterogeneous technologies and the effective use of virtual worlds both online and offline, it is necessary to define universal protocols. In this sense, the standardization of the virtual worlds has already begun [62,63].

However, in this design and standardization, it is important to consider the accessibility factors by groups of trainees, and trainers with special needs, as well as universal rules for enhanced inclusion in the Metaverse and virtual worlds. Accessibility needs should be analyzed in-depth and standardized in guidelines for human-computer interactions, as well as for existing and emerging multisensory representations of data and information (RQ2–RQ4).

2.2.5. Artificial intelligence in training and education

The field of AI has made huge leaps in recent decades. Especially nowadays, AI has been enhanced in all areas of everyday life [24–30]. The contribution of smart devices and the capabilities offered by Web X.0 have greatly helped in user's widespread spread and adoption [28]. Generative AI utilizes machine learning, neural networks, and other techniques to generate new multimedia content through the analysis of patterns and information from the training data [30]. This has enabled generative AI to have a wide range of applications, from creating personalized content to improving business operations [28,30]. Explainable AI (XAI) is an explainable model that provides insights into how the predictions are made to achieve trustworthiness, causality, transferability, confidence, fairness, accessibility, and interactivity [24,64]. When an AI model outputs a decision, it is strongly recommended to be understandable for the public [26,27]. Another trend is the addition of biofeedback and AI in simulation training and serious games with a significant impact in improving the effectiveness of training through increased engagement, motivation, and retention of information [29] (RQ4).

Metaverse is expected to emerge as a new paradigm for the next-generation Web X.0 [2,3]. While AI itself has many potential applications, ensuring the security of AI in critical applications like extended reality applications is profoundly crucial to avoid undesirable actions that could undermine users' privacy and safety, consequently putting their lives in danger [25]. To this end, security, privacy, and trustworthiness aspects associated with the use of various AI techniques in Metaverse applications are needed [25]. In addition, further analysis is required for the advancements that AI could cause, in the common effort for enhanced accessibility and inclusion in the Metaverse for education and learning purposes. In a broader sense, it is necessary to set humans in the loop, while designing and developing educational virtual worlds (RQ4).

2.2.6. Initial endeavors in XR training and education

The dynamics of immersive technologies and their potential to contribute to the more active participation of learners in the learning process have been exploited by

recent initiatives. Innovative training programs contribute to the development of participants' skills in cutting-edge technologies. In parallel, new educational frameworks and platforms are being developed to adopt and disseminate immersive technologies as effective interpretive and collaborative tools in education and training. Illustrative examples are presented in **Table 1**. Although the specific examples are not cases of virtual worlds, they could contribute to the effort to frame the development of inclusive and accessible virtual worlds in education and training.

Table 1. Initiatives in XR training and education.

Endeavor	Type	Description
VR-Games Lab [65]	training program	Blended lifelong learning program on the use of 3D graphics and serious games in VR for education, training, and cultural heritage.
Think XR [66]	training program	Establishes a curriculum and new teaching modules in the field of AR and VR.
Vol3DEdu [67]	training program	Trains European teachers to address their digital transformation through XR content development and apply innovative XR-based curricula in their pedagogical strategies.
XR4ED [68]	education platform	On-demand education platform that will provide centralized access to existing XR content, tools, and solutions, based on open standards for learning and training.
XR2Learn [69]	education platform	Establishes cross-border creation of human-centric XR applications in education and enhances training in manufacturing and distance learning scenarios.
MASTER [70]	education platform	Open XR platform that integrates key functionalities for creating safe robotic environments and delivers rich training content on robotics, and didactic material.
BRIDGES [71]	education platform	A holistic solution for group interaction in room-scale immersive XR environments that blend the physical and virtual space.
XR Initiative [72]	infrastructure	Engages the University of Michigan community with knowledge and content through immersive technologies.
VReduMED [73]	framework	Develops a roadmap for VR training products and services and publishes a handbook on the integration of VR into health care education.
Alliance4XR [74]	framework	Empower educational institutions and vocational training centers to integrate XR into education in structural engineering, energy, and maritime.

3. Results

This section describes the application of virtual worlds in training, education, and lifelong learning. The aspects of accessibility and inclusion for all education and training actors are highlighted.

3.1. Challenges in training and education

Due to the outbreak of the pandemic, there was an urgent need to adapt many educational systems of formal learning to distance learning. Several video teleconferencing systems have turned into useful tools for the educational process. Under the extreme circumstances, new ideas emerged for a more humane and entertaining experience in distance learning. The conference sector was the area that was significantly affected. Its reflexes were immediate and experimental virtual meeting rooms were created to serve the delegates. The combination of these two indicative cases could produce a new experience and possibilities in education and the training industry, as complementary support not only in emergencies but especially in normal conditions. However, the factors affecting accessibility and inclusion in digital solutions for remote participation in distance learning and training or conferences

should be considered during their design and development. In this way, barriers related to access to infrastructure and equipment, content, and services will be reduced, as well as the limitation of technophobia caused by the specific solutions.

Immersive technologies can provide remarkable experiences to education and training actors as they can revive historical incidents, safely face dangerous situations and can be transferred to any space that exists or not. Focusing on the sector of formal education, students could participate in chemistry experiments with absolute safety through innovative XR tools [75] in educational virtual worlds. At the same time in lessons of history, they could act as a glorious persona. The application of the virtual worlds in the educational process could provide radical learning experiences. From the perspective of training, which is more oriented to adult education, virtual worlds could similarly enhance the level of readiness for the workers of a factory in maintenance work or conditions of emergency and dangerous events. However, the disciplines and theories governing curriculum design should be adapted and applied to the case of virtual worlds in education and training.

3.2. Application of virtual worlds in training and education

Virtual worlds can be used as educational and interpretive tools in the learning process in formal education. The development of virtual laboratories for various science areas such as physics and chemistry has made significant progress in recent years in secondary education. Additionally, laboratory simulation and gamification of procedures in medicine and health have led to the development of immersive and realistic virtual worlds for training students in demanding and stressful surgical procedures. Correspondingly, virtual worlds are used on a large scale to train personnel in critical, extreme, and dangerous situations, both by security and civil protection bodies, and by workers in industry. In all the cases mentioned above, the virtual worlds are part of a wider educational context that aims to practice and apply the knowledge acquired in a learning program.

Virtual worlds could also be used as systems for conducting blended learning programs. They could replace the provided and obsolete online educational platforms used for synchronous or asynchronous distance learning. Today, the educational materials developed and used in blended learning programs are based primarily on text, audio, images, and video. However, virtual worlds could offer upgraded services to those involved in the educational process, incorporating new types of representations and experiences, thanks to the achievements of immersive technologies and creative industries. For example, integrating virtual classrooms into an online training platform to practice knowledge through augmented reality equipment could enhance the effectiveness of the educational process. A practical application would be learning representational arts such as painting in a virtual workshop with the instructor's presence or an avatar guide, supported by explainable artificial intelligence.

Virtual worlds could also be used as independent and autonomous educational platforms, without combining or depending on any physical or blended educational and training program. Autonomous virtual worlds for education could be developed with immersive technologies and creative industries, which through gamification could be used as educational products for standalone and offline use by any interested

party. Also, these virtual training worlds could be developed for use over the web, especially where learner-to-trainer or learner-to-learner interaction is required. In addition, stand-alone online virtual worlds could be the ideal choice when user evaluation of the achievement of the learning objectives of the educational program is required. The open-source architecture of WebXR, as well as subscription platforms for hosting and developing virtual worlds could be used to create educational programs in the Metaverse.

3.3. Accessibility and inclusion in virtual worlds for training and education

The application of virtual worlds in training and education could overcome any obstacle related to physical infrastructures or instrumental equipment. In this sense, 3D graphics could be used to create the shell and the functional assets of any virtual educational and training case. Undoubtedly, virtual simulation of educational environments could positively enhance access to the educational process. However, the simultaneous development and integration of multimodal and multilevel representations of information could further enhance the accessibility factor. In addition, the universal integration of real-time translation functions, especially through artificial intelligence could strengthen inclusion in the training process, especially in cases where the target group is multicultural. Moreover, adapting the content and dynamically adjusting the usability of the virtual learning world system through algorithmic analysis of learner behavior could further enhance inclusion and accessibility. Finally, the multisensory representation of information and interactions, beyond enhanced user immersion, could in several cases be an additional element for more accessible and inclusive virtual worlds of education and training.

4. Discussion

Virtual worlds could be applied to many aspects of socioeconomic life. They could increase the capacities of an enterprise or improve the conditions and mental health of the employees in the workplace. Virtual worlds could also be used for enhanced participation and expression in democracy, as well as in cultural and creative industries of audiovisual arts and performances. Undoubtedly, they can also play a key role in retail and customer experiences, or the transport and tourism industry. In parallel with their development, virtual worlds should address a set of issues that have arisen. Regarding the technical challenges, the privacy and security of user's personal and sensitive information should be considered. From the perspective of societal challenges, ethics, and human rights in the virtual world should be protected. As for the governance and policy challenges, virtual worlds should be in alignment with fair governance models, as well as with existing policies and laws. In any case, inclusion and accessibility should be key aspects of designing and developing virtual worlds.

4.1. Human-centered virtual worlds

Educational virtual worlds should place humans in the center of their architecture. To this end, virtual worlds should be by design inclusive and accessible, as they will be developed according to accessibility pipelines for digital productions and web-

based services. The fact that they include almost all the senses, learners and instructors can take advantage of the combination of those that better serve their needs. Also, the multimodal representation of information provides the possibility for the user to interact without problem with the elements of the educational virtual world. In addition, the development of the virtual worlds should consider the influence on human health, as well as on user psychology. As the virtual worlds will be the spaces for social interaction among trainees and educators of real and virtual life, it will be important to include social sciences and humanities for shaping even more human-centered virtual environments (RQ1).

However, as virtual worlds are envisioned to co-exist and interact with the real world, accessibility and inclusion should be the main feature in every manifestation of socio-economic life. The design and development of the virtual worlds should be an interdisciplinary process that will involve social and humanities, as well as health sciences.

4.2. Accessible and inclusive content in virtual worlds

The content that makes up educational virtual worlds should be designed in such a way as to facilitate access to data and information by all users. Special emphasis should be given to multimodality and the adaptation of information and its representations according to the personal needs and abilities of the learners and educators. Therefore, the colors and contrasts should be adjusted when the user is facing issues with color blindness, as well as the possibility to increase and decrease the font size of the texts in case the user is facing problems with their vision. Certainly, voice guidance within virtual worlds could work helpfully for all users even those without any visual disorder. A critical functionality of educational virtual worlds that could enhance diversity inclusion is translator integration. In this way, barriers related to understanding the language could be removed (RQ2).

However, accessibility and inclusion regarding the content of learning virtual worlds should be extended to all assets that will be reused from digital collections repositories and datasets. Therefore, it is necessary that both the new data that will be stored in repositories, as well as the already stored data that will be reused, comply with specifications that ensure easy access and facilitate the inclusion of all users.

4.3. Standardization in virtual worlds

Educational and training virtual worlds offer a suitable space for heterogeneous emerging technologies to be used and developed separately or in combination with others. The adaptability of the game engines, to extend and include different types of technologies is expected to enhance the development of the learning virtual worlds. The rapid development and spread of artificial intelligence advocates in this direction. Through explainable AI the users of educational virtual worlds will be able to interact with virtual characters and receive assistance and guidance more understandably and humanly. Haptics and olfactory could enhance user satisfaction, through the improved multisensory immersion. Furthermore, the possibility of integrating multimodal and multisensory user interaction with digital elements could under certain conditions enhance the accessibility and inclusion of users in educational virtual worlds (RQ4).

With the full support of next-generation connectivity, such as Web 4.0 and 6G networks, the near-to-zero latency is expected to deliver advanced immersive experiences into the virtual worlds.

However, specific and universal standards should be established to make heterogeneous technologies and equipment work properly and efficiently for end users. Standardization should not only be limited to how technologies will communicate with each other, but above all, they should prioritize people and holistic access and inclusion in educational and training virtual world services (RQ3).

4.4. Ethical issues

4.4.1. Social isolation

A crucial issue that should be explored in depth is the impact of virtual worlds on human socialization, as well as the potential to fuel the digital divide, especially in the context of accessibility, education, and training. The Metaverse is designed to combine real life with advanced services and experiences in the virtual realm. This means that every person will be able to interact in a more advanced way with users from all over the world, thanks to immersive technologies and the ever-increasing bandwidth of networks. This could exacerbate the social isolation of users from real life, as they will spend more time in the digital world, replacing social relationships and interactions in real life. This perspective could have negative consequences for the mental health of the person. At the same time, social isolation and conscious abstinence from real social life could negatively affect social cohesion. Therefore, there should be a balance between the socialization offered by virtual worlds and real life, as well as the judicious use of the services and goods offered by the Metaverse. In any case, nothing can replace the real need of every human being to interact with the social context, without limitations and exclusions.

4.4.2. Privacy and security

In the blended use of virtual worlds and real-life, the use of data related to personal and sensitive information of users is expected to increase significantly [76]. Even though several efforts are being made and appropriate frameworks are being formed to ensure the privacy of users' data, it is reasonable to raise serious concerns about how users will ensure the privacy and security of their data. Many users are wary of how their data could be used by complex and multidimensional virtual worlds. On the one hand, the establishment of the use of AI undoubtedly offers new possibilities and personalized services to users but has as a basic condition the use and processing of user data. On the other hand, there are not a few examples and highlights of the risks and threats arising from the illegal or questionable use of data by AI algorithms. In addition, in the new situation that is taking shape with virtual worlds, it is necessary to put the protection and security of personal data and information as a top priority.

In this direction, special care and attention should be given to ensure privacy in educational virtual worlds. Guidelines should be designed, developed, and adopted for the privacy and security of personal data in learning virtual worlds. However, they should also take into account the particular circumstances that arise to incorporate functionalities that will contribute to enhanced accessibility and user inclusion. Therefore, the complex topic of personal data protection, privacy, and information

security in accessible and inclusive virtual educational worlds should be studied further and multi-layered. The close collaboration of researchers, developers, and all the actors involved in the educational process through virtual worlds is a one-way route.

5. Conclusion

The scope of this article was to predict the influence of the virtual worlds in training and education, as well as to contribute to shaping inclusive and accessible blended ecosystems of real and virtual life. The existing conditions in a wide spectrum of heterogeneous technological and scientific sectors favor the application and strengthening of the use of virtual worlds in everyday life. Mature and emerging technologies could be combined harmonically through the virtual worlds to offer new possibilities in socioeconomic life. The blend of reality with virtuality could provide more inclusive and accessible services horizontally. The application of virtual worlds could overcome barriers related to distance, time, and risk. The integration of virtual worlds into everyday life could lead to the economic well-being of people and the development of new economic models with equal access for all. Virtual worlds could also play a key role in achieving the green deal by directly or indirectly replacing environmental burdens.

However, we are at a critical point where we need to take seriously the needs, demands, and opportunities when designing the Metaverse and virtual worlds. Exploiting technological achievements and developments will be instrumental in shaping and enhancing accessible virtual worlds. Limiting and eliminating barriers and obstacles will lead to enhanced inclusion in the Metaverse era. In this direction, policymakers, researchers, and developers should work closely with those directly involved in education and training to further develop accessible and inclusive virtual learning worlds.

The main limitation of this study is that it is a conceptual methodology, which proposes a theoretical framework. It is part of the wider effort to shape the context for enhanced accessibility and inclusion in virtual worlds especially in education, learning, and training. As for future work, it is suggested to further develop the proposed framework on an interdisciplinary basis, through experimental tests and analysis of initial results in prototyped educational virtual worlds.

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