ADVANTAGES AND DISADVANTAGES OF THE METAVERSE IN THE LEARNING OF STUDENTS WITH DISABILITIES: CRITICAL ISSUES, POSSIBILITIES AND NEW PERSPECTIVES

VANTAGGI E SVANTAGGI DEL METAVERSO NELL'APPRENDIMENTO DEGLI STUDENTI CON DISABILITÀ: CRITICITÀ, POSSIBILITÀ E NUOVE PROSPETTIVE

Dario Lombardi
Università di Foggia
dario.lombardi@unifg.it
0000-0002-3405-6016

Luigi Traetta
Università di Foggia
luigi.traetta@unifg.it
0000-0001-7785-9751

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ABSTRACT
The Metaverse is an immersive digital environment that combines physical and virtual reality. Its applications in education are growing, but studies on how it can benefit or harm students with special educational needs are still lacking. This paper presents a Systematic Literature Review (SLR) to examine the advantages and disadvantages of the Metaverse in teaching students with intellectual disabilities. The results will be analysed and discussed in the meta-synthesis phase.

Il Metaverso è un ambiente digitale immersivo che unisce realtà fisica e virtuale. Le sue applicazioni nell'istruzione stanno crescendo, ma mancano ancora studi su come possa beneficiare o danneggiare gli studenti con bisogni educativi speciali. Questo documento presenta una Systematic Literature Review (SLR) per esaminare i vantaggi e gli svantaggi del Metaverso nell'insegnamento agli studenti con disabilità intellettive. I risultati saranno analizzati e discussi nella fase di meta-sintesi.

KEYWORDS
Metaverse, Disability, Virtual Reality
Metaverso, disabilità, realtà virtuale

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1. Introduction[1]

The first time the Metaverse is referred to in literature is in 1992, within Neal Stephenson's novel Snow Crash. In the novel, the protagonists operate in a three-dimensional virtual universe, referred to as the 'Metaverse'. Etymologically, the word 'Metaverse' is derived from the combination of the prefix 'meta', meaning 'beyond', and the noun '(uni)verse', 'universe' (Accademia della Crusca, 2023). On 28 October 2021, Mark Zuckerberg, CEO and founder of Facebook and Meta, launched the Metaverse, defined by Lee (2021) as: "a virtual, three-dimensional reality in which everyday activities and economic life are conducted through avatars that represent reality itself". The avatar is a virtual alter ego, employed by the user for the performance of social, economic and cultural activities within a multi-user, perpetual and persistent environment that merges physical reality with digital virtuality (Kye et al., 2021). The fields of application of the Metaverse are many and continue to grow exponentially (Donaldson, 2011). Initially used for recreational purposes, particularly video gaming, the Metaverse is now the preferred interaction context for: conducting business meetings and interviews, providing healthcare services, treating patients with psychiatric disorders, providing support for people with disabilities (Contreras et al., 2022), and ensuring effective educational interventions for learners (Prasetyo, 2022). In spite of the potential of the Metaverse in education, according to Tilli and colleagues (2022), a year ago no literature review had yet been conducted to summarise the findings regarding the Metaverse in education. There are several questions that need to be answered by the research world, especially with regard to the application of the Metaverse for the education of students with disabilities, since, according to Tilli's first-mentioned research, there are far too few studies on the effects of the Metaverse on the education of students with disabilities. For these reasons, it was decided to conduct this study in order to help shed light on the advantages and disadvantages of using the Metaverse in teaching people with intellectual disabilities. The intention is to analyse how the Metaverse and virtual reality can affect, positively or otherwise, the educational performance of students with intellectual disabilities and to elicit the educational possibilities linked to the use of these technologies in the world of special education.

[1] Although it is to be considered joint research,
paragraph 4 is attributed to Luigi Traetta
and 1-2-3-5-6-7 to Dario Lombard

2. Literature Review

2.1 Planning the Review

This systematic literature review aims to define the current state of knowledge and studies with regard to the application of the Metaverse and virtual reality systems in the education of persons with intellectual disabilities. The following illustrates how the process of selecting and reviewing the identified articles was conducted, using the PRISMA flowchart (Fig.1).

2.2 Selection Criteria and Search Requisites

The inclusion and exclusion criteria applied in the review will be outlined below, in order to select the articles from which information will be deduced to answer the question of this review study.

Inclusion Criteria	**Exclusion Criteria**
Papers must be relevant to the research topic and area	Papers that were published before 2019
Papers are recognized internationally	Paper are not written in English
Papers implementing virtual-based learning	
Papers must provide interventions for people with ID	

Table 1. Selection Criteria

Below are the keywords used when searching the databases: Scopus, ERIC and PubMed.

Database	Search Terms
Scopus PubMed ERIC	(Metaverse OR Virtual Space) AND (educat* OR teach*) AND Disability

Table 2. Search Terms and Database

3. Background and Research Question

The Metaverse and virtual reality are at the centre of attention of teachers and trainers, as its use in today's and tomorrow's educational practices is becoming increasingly evident. Several researchers have been discussing the use of virtual systems and the Metaverse in education for some time. Kemp and Livingstone in 2006, hypothesised the combination of the Metaverse with Learning Management Systems (LMS), through the use of the virtual world "Second Life". Collins (2008), dwelling on the concept of virtuality, argued the Metaverse's potential for socialisation between people and its suitability to promote meaningful learning and teaching for students. The advent of immersive technologies such as virtual reality (VR), mixed reality (MR), augmented reality (AR) and extended reality (XR) has resulted in a promotion of the metaverse within educational contexts. One of the advantages of virtual spaces is that they allow students to attend their lessons at a distance, with the advantage of being able to rely on the use of objects, analogue and virtual, and modes of interaction, typical of face-to-face teaching. This can lead to greater student involvement. Virtual experiences can be applied to children and adults (Cadet et al, 2022), linking students and teachers within virtual classrooms and laboratories, useful for teaching any subject and suitable for any course of study, especially scientific subjects such as computer science, physics, chemistry, medicine and earth sciences (Reeves et al., 2021; Chang et al., 2020). Reyes (2020) made use of the Metaverse and augmented reality (AR) in a study on mobile

learning for teaching mathematics, Gonzales Crespo et al. (2013) investigated the applications and effectiveness of virtual learning paths using OpenSim. Park and Kim (2022), identified the different types of metaverse developed for educational purposes. It can be inferred from these studies that research on virtual learning environments is growing, however, as reported by Tlili and colleagues (2022), research and studies on the metaverse concerning persons with disabilities are lacking. It should be analysed how these cybernetic and virtual spaces, quintessentially devoid of spatial and temporal limitations, and especially of materially barrier elements, can ensure effective educational interventions for learners with disabilities. Technologies have the potential to act as compensatory tools for people with impairments or disorders. In this study, we were interested in verifying what is the state of research in the studies on virtual reality in teaching people with intellectual disabilities, because the incidence rate of this condition is significant in the world population (Maulik et al., 2011) and the most frequent in the national territory and in Italian state schools (69.8% in the 2018/2019 academic year)(MIUR, 2019). During the Covid 19 pandemic, students with disabilities were not allowed to have their educational content delivered in an effective and personalised manner due to restrictions. A greater understanding of how to use technology and virtual contexts would have been desirable at the time of Covid-19, and needs to be pursued now, in order to ensure quality education for all students, including those with disabilities, and in particular for those with intellectual disabilities, who make up the bulk of the category. For the following reasons, the following study aims to ascertain:

- RQ 1 - What are the advantages, disadvantages/limitations and future prospects regarding the use of the Metaverse and virtual systems with regard to students with intellectual disabilities?

4. Methodology

The Present study was conducted following the paradigms of Systematic Literature Review (SLR) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Selcuk, 2019). The PRISMA model was chosen because it provides a standardised and reliable research methodology and uses a guideline checklist. The purpose of this choice is quality assurance of the review process and its replicability. A review protocol was developed that describes the article selection criteria, search strategy, data extraction and data analysis procedures.

4.1 Data sources and search strategies

There were three databases through which the articles were retrieved, namely ERIC, Scopus and PubMed. The time frame for the search of the articles for this SLR was from 2019 to 2023. Within the search bar of each database, the following keywords were entered: (Metaverse OR Virtual Space) AND (educat* OR teach*) AND Disability. Following the search Scopus identified 28 articles, PubMed 10 and ERIC 28. The studies were uploaded onto the artificial intelligence platform Rayyan, through which duplicate studies (10) were resolved and thanks to which the selection and review phase was easier, after reading the titles and abstracts.

4.2 Selection of studies

The titles and abstracts were selected independently by the reviewers (DL and LT) who applied the eligibility criteria mentioned above (Tab.1) to determine the eligibility of the papers to be included in the study. Once the selection phase of the papers was completed, after reading the abstracts, the full-text reading and final inclusion of these to the study was carried out. All discrepancies on the eligibility of the papers were resolved after discussion among the reviewers.

4.3 Data Extraction Process

Data extraction and quality assessment of the articles were performed by both researchers independently. The extracted data were recorded in the Data Extraction Table. Any discrepancies were resolved after discussion between the researchers.

4.4 Eligibility Criteria

The selection of articles took place in three rounds. The first selection round, conducted independently among the researchers, involved screening the title and abstracts. The second selection round involved the full-text reading of the articles to check their inclusion in the review study. Selection criteria were established according to the research question, data were extracted using the Mural platform and organised within the Data Extraction Table (Tab.3). Articles whose full text

could not be found were eliminated (1). In the third step, the researchers proceeded with the inclusion of the data within a single document and all documents that did not describe the application of virtual systems and the metaverse for the education of students with cognitive disabilities were excluded.

4.5 Constitution of the Corpus of Analysis

The studies were organised by year of publication. The analysis and evaluation of their content was based on strategies and procedures developed by Bardin. The search, following the first review for abstracts and paper titles, selected 9 articles, of which the entire article of one (1) study could not be found.

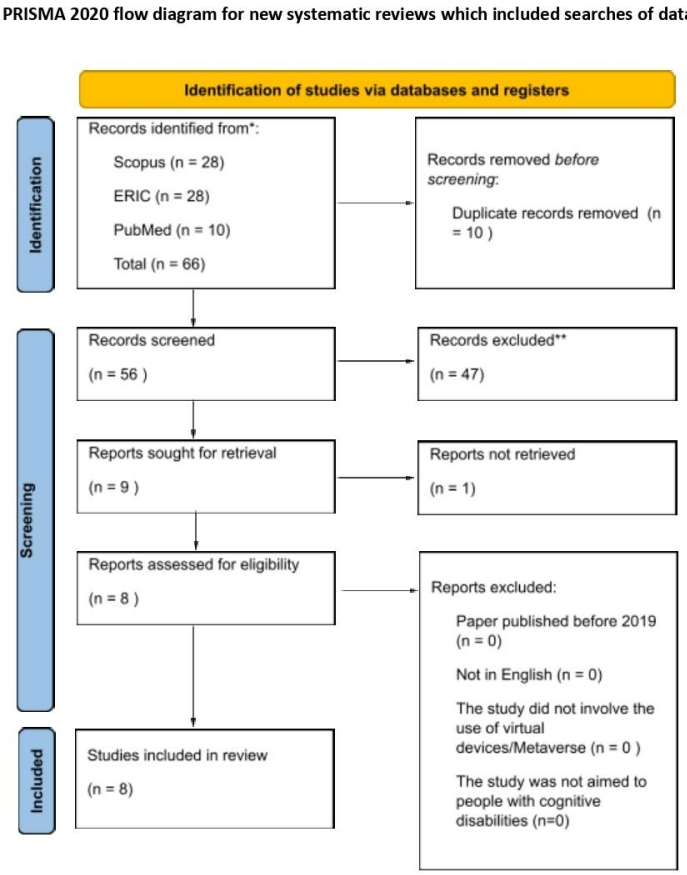
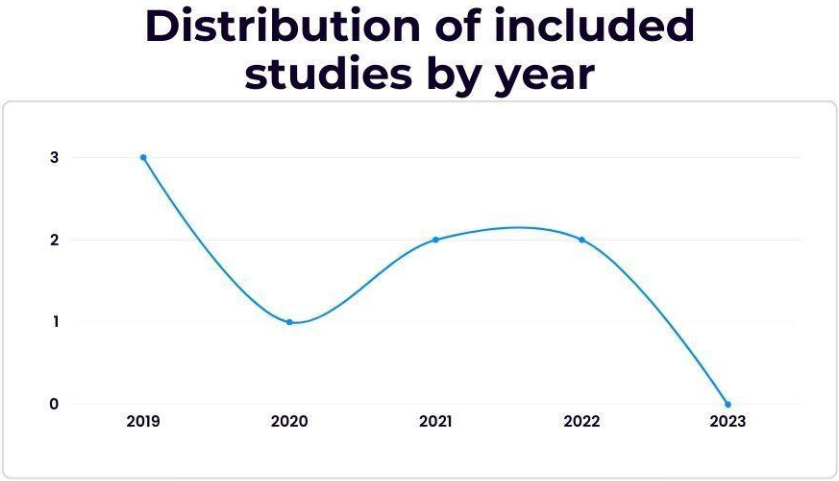


Fig.1 PRISMA flowchart

4.6 Characteristics of the included studies

The number of studies published for each year was graphically represented. The year with the most included studies published is 2019 (3). From the survey carried out, for the time being it does not appear that any studies useful for this systematic review have been published for 2023, while one (1) of the included studies was published in 2020 and two studies (2) for both 2021 and 2022.



Graph. 1 Distribution of included studies by year

Data extraction table included studies - Tab.3

5. Results

This section will present the results of the data collected from the studies included within this SLR, organised in order to answer the research question.

5.1 Advantages of the Metaverse and virtual systems

Within the study by Kang & Kang (2019), reference is made to the use of virtual systems in adapted physical activity (APA), i.e. that "diversified programme of developmental activities, play, sports and rhythms adapted to the interests, abilities and limitations of students with disabilities who cannot safely or successfully participate in the rigorous activities of the regular (general) physical education programme" (Committee on Adapted Physical Education, 1952). The authors argue that through the use of virtual systems in APA, students can experience new sports an unlimited number of times, and this is of paramount importance in consolidating the acquisition of essential motor patterns in persons with disabilities. VR systems are also cost-effective as, after the initial investment, it is sufficient to purchase additional small components or devices, which can be upgraded at negligible cost. VR systems allow the customisation of the educational and physical experience according to the user's needs and capabilities. It is also emphasised that such systems are able to prevent the risk of injury during exercises, as the user is able to operate within controlled contexts. The student, in VR contexts, is subjected to sensory pluristimulation, can perceive the trajectories, impulses, speed and gravitational acceleration of the objects with which he or she interacts in virtual contexts. This contributes to his physical and cognitive rehabilitation, as well as to meaningful learning.

In the study by Bouck and colleagues (2019), the scholars engaged in teaching 3 students with intellectual disabilities in middle school mathematical concepts related to fractions through the use of the abstract virtual (VA) teaching sequence. The VA teaching sequence is a step-by-step instructional procedure in which students acquire numerical strategies for solving mathematical problems through interaction with virtual manipulatives (Bouck et al., 2017) . As a result of the VA intervention, students had acquired more skills in solving problems with fractions than in traditional education. Scholars claim that the VA teaching sequence is an effective intervention strategy for students with intellectual disabilities. VA teaching speeds up the learning time of students with ID and is also appreciated by teachers.

Root and colleagues (2021) tested the effectiveness of virtual reality in making three middle school students with autism spectrum disorders and intellectual disabilities acquire skills in the study of multiplication. In the study, Bouck's (2018) Virtual Representation Abstract (VRA) is applied, i.e. a sequence of instruction in which students are taught how to approach a mathematical problem, through the use of manipulatives and virtual devices (Bouck et al., 2017). In the study, a functional relationship between the VRA-I framework and students' problem-

solving accuracy is shown. Through the intervention with immersive viewers, the students generalised the skills and applied them in real life. There was minimal regression in problem-solving accuracy during the transition from virtual intervention to representation and abstract conceptualisation. Participants demonstrated a broad conceptual understanding of the targeted skill and demonstrated problem-solving skills using virtual, representational and abstract methods.

In the study by Downey and colleagues (2022), a multiple probe design was used to examine the acquisition of behavioural literacy-based interventions (LBBI) during virtual job interviews by three university students with autism spectrum disorders (ASD) and intellectual disabilities. Thanks to the implementation of an LBBI e-book, all students increased their accuracy, their level of mastery in handling the interview and achieved maximum test scores. They enjoyed the intervention and the results achieved were maintained over time, even after the experiment was completed.

In the article by Bone and colleagues (2022), virtual manipulatives were tested to support the learning of algebra of three students with intellectual disabilities in middle school. In the study, the researchers found a functional relationship between the VA framework, first mentioned in the study by Bouck and others (2019,) and the students' ability to successfully solve school-level algebra problems. All students, following the intervention, demonstrated the ability to solve more algebra problems and maintained their accuracy in solving them even after the intervention was discontinued. The problem solving skills acquired through the VA framework were translated into real transversal skills. Finally, it is emphasised that the teaching intervention, mediated by the use of virtual devices, is customisable in relation to the student's abilities, skills and learning time.

The article by Long and colleagues (2021), on the other hand, discusses how, from an inclusive perspective and open to multiple types of cognitive disorders and disabilities, educators can adopt explicit instruction for distance education within a virtual environment. The article is descriptive in nature, presenting virtual, representational and abstract manipulative resources as well as the various modes of content delivery, i.e. synchronous, asynchronous, independent and guided. The study, analysing multiple types of interventions delivered in schools of various grades, reports how explicit instruction, defined as "a group of research-supported instructional behaviours used to design and deliver instruction that provides the

supports necessary for successful learning through clarity of language and objectives and reduction of cognitive load" (Hughes et al., 2017), is useful in order to make students acquire useful and permanent mathematical skills over time. According to scholars, explicit instruction can be successfully adapted to teaching mathematics to students with mild, moderate and severe cognitive disabilities in online settings.

The study by Bouck and colleagues (2020) aimed to test an intervention package for teaching multiplication and division to four students with disabilities and autism spectrum disorder in middle school. Following the intervention, the students improved their problem solving and multiplication and division skills. They also learnt to represent operations graphically. All skills were maintained by the students over time and during lessons, the students were motivated by the use of virtual devices.

In the study by Hu and colleagues (2019), the effectiveness of using gesture-based instruction via virtual reality (VR) to teach matching skills to three primary school students with autism spectrum disorders was investigated. As a result of the intervention, all students improved their test scores and showed increased engagement in task performance. The teachers were enthusiastic about the reduction in time needed for lesson preparation through the use of VR and Leap Motion technology. The participants in the experiment demonstrated greater collaboration and cooperation during the intervention sessions and retained the acquired skills for three months after the experiment.

5.2 Disadvantages and limitations of included studies

In the study by Kang & Kang (2019), among the disadvantages in disability education are the dangers of using VR systems in children under the age of 7. Indeed, due to their age, they may have difficulty distinguishing reality from virtual representations. Furthermore, it is recommended to limit the use of VR devices in children and adolescents with anxiety, depressive or ADHD disorders.

In the study by Bouck and colleagues (2019), it was shown how disabled students reacted to the teaching of mathematics by means of the abstract virtual sequence (VA). The benefits were manifold, but among the disadvantages, it was highlighted that the students struggled to maintain the acquired skills at the end of the intervention.

Disadvantages and problems found in the paper by Root and colleagues (2021) included: a potential study bias due to the predictability of the tests administered to the students; the fact that educational institutions do not always have virtual devices; and the fact that the skills gained by the students as a result of the intervention are not generalisable and transposable to real-world problem-solving.

In the study by Downey and colleagues (2022), several problems were found. As in the aforementioned study by Root (2021), students may have shown increased confidence in the interview as a result of the fact that the interview did not change between simulations. The scholars emphasise that a limitation of the use of VR systems in teaching cognitively impaired students could result from the sporadic malfunctioning of the devices. The study also has a limitation in that it did not investigate the acquisition of soft skills in students during the conduct of the interview.

In the study by Bone and colleagues (2022), a limitation was found with regard to the subject chosen to conduct the study, in fact, one student expressed deep frustration during the experiments, as she did not understand mathematics.

Long and colleagues (2021) argue that in a virtual environment, due to technological problems or the organisation of educational interventions themselves, it is more difficult to provide explicit instructions for the execution of teaching activities. These complications could affect and hinder the normal continuation of the lesson planned by the teacher.

For Bouck et al. (2020), there are limitations in their study; they claim, in fact, that it is not possible to determine which particular elements of the conducted experiments determined their success.

In the study by Hu & Han (2019), the need to develop more academic virtual games for the development of fundamental skills in students with cognitive disabilities and ASD is asserted.

5.3 Future perspectives

Regarding future perspectives on the use of virtual devices in education for people with intellectual disabilities, Kang & Kang (2019) argue that when Artificial Intelligence (AI) is applied to virtual reality, there will be significant changes in the sports education of people with physical and intellectual disabilities.

For Bouck and other scholars (2019), it is necessary to continue with experiments, but with the use of other virtual devices and different interaction modes.

Root and colleagues (2021) argue that the use of the VRA can improve students' problem-solving skills. The researchers anticipate that in the future, leveraging multiple teaching methods involving the use of VR systems will provide students with a greater range of useful coping strategies. This would positively affect their confidence and their independence and autonomy.

Downey and colleagues (2022) argue that in the future, it will be necessary to implement virtual and distance working skills for students with disabilities. According to the scholars, these systems will have to be leveraged to ensure that they acquire skills that can be used in the labour market.

Bone and colleagues (2022) envisage further experiments with the VA framework and other types of virtual manipulation on more advanced and complex algebra concepts. Bouck and others (2020) assert the need to promote the use of virtual reality devices in people with cognitive disabilities and ASDs.

Finally, Hu & Han (2019), advocate for the development of more academic games for the development of the core competencies of students with ASD and the integration of: visual prompts, systems for customising time, multimedia reinforcement and functions for peer instructional mediation, in Leap Motion-mediated virtual learning interventions.

6. Discussions

From what was analysed, it was found that most of the articles included in the Review, involve the application of virtual devices and frameworks in the study of mathematics (Bouck et al., 2020; Bouck et al., 2019; Root et al; 2021; Bone et al., 2022; Long et al., 2021). The application of virtual devices for teaching has proven particularly effective, resulting in significant gains in the understanding of multiplication, division (Bouck et al., 2020; Root et al., 2021) and fractions (Bouck et al., 2019) by students with cognitive disabilities and ASDs. The improvements found in the students were sustained (Bone et al., 2022) and various methodological approaches were applied through the use of virtual manipulatives (Bone et al., 2022; Bouck et al., 2019). Virtual reality is also effective for teaching adapted physical activity for people with cognitive disabilities (Kang & Kang, 2019) and is useful for acquiring skills that are expendable within the labour market

(Downey et al., 2022) and aimed at providing students with disabilities with greater autonomy and self-confidence. No articles were found that envisaged the application of virtual devices to make students acquire functional literacy skills. It would be desirable for research in the near future to be oriented towards developing mother tongue and foreign language skills through peer interaction mediated by virtual educational spaces and devices. An interesting practice could be Virtual Storytelling, which has already been tested on people with intellectual and developmental disorders (IDD) by Gelsomini and colleagues (2016). Virtual reality should also be used to enable people with cognitive disabilities and generalised developmental disorders to acquire skills in managing reality tasks, within educational and, in particular, inclusive contexts. In order for teachers to learn how to integrate virtual technologies into teaching and acquire more digital skills, it is desirable in the near future to include the application of virtual systems in teacher training courses. It is also necessary to enhance the multimedia systems available to educational institutions so that the use of Virtual Based Learning can be facilitated during lessons. In order to diversify teaching offerings, ensure greater customisation of educational interventions and make lessons more engaging, it would be advisable to continue investing in the development and application of virtual learning games. These should also be made available in more languages, so as to promote their use in different countries. It is necessary to reflect on the potential of virtual devices and the Metaverse in education. The use of the Metaverse, in the near future, could become commonplace in school and academic contexts. Continuing to research what applications it may have in the field of didactics and special pedagogy is a civic and moral duty and a challenge that the world of research cannot shirk.

7. Conclusions

The aim of this Systematic Literature Review was to elicit what the advantages, disadvantages/limitations and future perspectives are with regard to the application of virtual devices and the Metaverse for people with cognitive disabilities. The advantages found were manifold, the students involved in the studies included in the review demonstrated considerable improvements, permanent over time, and strong motivation when interacting with virtual devices. Virtual reality also facilitated the work of the teachers, who were interested in the implications of VR in teaching, and found greater cooperation and collaboration among the students during experimentation. In the future, the Metaverse could become fully integrated into educational practice, and its implications in special

education could be truly significant and inclusive. The Metaverse and virtual spaces, as places without spatio-temporal and physical barriers, can become laboratories of inclusion, open to all students, especially those experiencing situations of social marginalisation and with cognitive and physical disabilities. It is important to continue searching for new solutions to contemporary problems, projecting oneself and the horizons of educational research into the future. A fairer and more equitable future, oriented towards a conscious and competent use of technologies, and which makes the inclusive process its ultimate telos.

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