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Review

Exploration of Educational Possibilities by Four Metaverse Types in Physical Education

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Abstract: The metaverse has been evolving the internet-based education represented by e-learning. Metaverse technology is currently being developed as a platform centered on content-based information industries. It can be classified into four categories: augmented reality, lifelogging, mirror worlds, and virtual worlds. Although current research finds that the potential of the metaverse is not small in the education world, and metaverse technology is already being used in the sports world, concrete applications have not been investigated. The main aims of this study, which started with this purpose, can be summarized as follows. The metaverse environment is still in its rudimentary stage, and its use related to physical education subjects is only at the game level. In the future, the utilization of the metaverse by physical education subjects will be possible in universities only when more specialized technology is grafted into various sports. Ultimately, this study contributes to expanding the scope and depth of follow-up research by offering basic data showing the direction of metaverse-based physical education.

Keywords: physical education; metaverse technology; platform; e-learning

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1. Introduction

Due to the coronavirus pandemic that broke out in 2019, we currently live in a contactless society, and numerous efforts are being made to return to the contact society that existed before 2019 [1]. It would not be an exaggeration to say that we are currently living in a "new normal" era, mixing contact and contactless interaction. In education, the metaverse concept of using education combined with technology (Edu+Tech) is spreading throughout the education world due to the prolonging of the coronavirus or corona-variant era, and the acceleration of the fourth industrial revolution. Some schools have used the metaverse to hold entrance ceremonies and orientations, and also for communication, and knowledge transfer and sharing. As studies show, various attempts to use the metaverse in modern society are being made in various fields [2]. In physical education, where practical classes are mainly used, the means of overcoming this problem should be explored in depth. Using Edu+Tech in the field of education can help to solve these problems to some extent. In other words, it is possible to solve difficult problems posed by online learning by incorporating the metaverse into physical education subjects.

Meanwhile, South Korea's Ministry of Education has recommended that university classes be switched to non-face-to-face online formats in consideration of the number of corona-infected patients [3]. When the number of infected patients decreased to some extent, the government recommended proceeding with offline classes, online classes, or mixed types of classes. Here, most of the professors and learners insisted on contact classes at the beginning of the coronavirus pandemic, but after experiencing two or three years of online classes, they recognized significant advantages, and by the time they felt that the coronavirus pandemic was more or less over, the number of professors and learners involved in online classes had increased [3,4]. However, the problem is that the types of online classes described above are limited to classes related to theories. When the class is concerned with practical skills, online classes are not easy to deliver [5,6].

The metaverse is a driving force in the evolution of internet-based education, previously represented by e-learning. Metaverse technology is currently being developed as a platform centered on content industries, such as games [7]. The use of metaverse technology in physical education could solve the following problems. First, the metaverse should provide interactive technology with a high sense of reality in the virtual world. Second, facilities that can enhance the sense of presence in augmented reality should be provided. Third, content should be provided that can simulate the movements performed in actual sports. At present, it is necessary to preemptively prepare a plan to respond to the learning demands of physical education in the "new normal" era, and improve educational efficiency. Therefore, in this paper, the concept of the metaverse is summarized, and the characteristics of each metaverse platform type are investigated in terms of their applicability in the practical classes of physical education. Additionally, based on these findings, by presenting a task-oriented physical education model that integrates four types of metaverse technology, this study intends to suggest a direction for metaverse-based physical education as a new alternative to non-face-to-face physical education. In addition, this study explored whether the four metaverse technologies can be used as a physical education curriculum.

2. Metaverse Technologies

Metaverse is a compound word comprising "meta" and "universe". Meta is a Greek word meaning "transcendence or more". Meanwhile, "universe", which means "world", refers to the actual world we live in. With the recent development of artificial intelligence-based technology, the imagined goals of mankind from about 30 years ago are being made into realities that we can experience, and the metaverse continues to develop as an expanded integrated space that connects the real world and the virtual world. Developers have avoided the dichotomous approach of viewing the metaverse as an alternative or opposite to the real world, as set out in the 2007 Metaverse Roadmap of the Acceleration Studies Foundation (ASF). Instead, it is understood as the junction, nexus, and convergence of the real world and the virtual world or virtual reality, thereby facilitating conceptual development. Recently, a view has emerged that the metaverse and the virtual world are to be regarded as the same concept, but the general view is that the real world and the virtual world are fused [8,9]. Table 1 summarizes the types of metaverses.

Table 1. The definitions of four metaverse types.

Classification	Definition	Reference
Augmented Reality	It is a technology that enhances work efficiency by augmenting virtual information in real space in real time and allowing users to interact with the augmented virtual information.	Kesim & Ozarslan, 2012 [10]
Lifelogging	It is a technology that captures, stores, and depicts everyday experiences and information about objects and people.	Gurrin & Smeaton, 2014 [11]
Virtual Reality	It refers to a specific environment or situation or the technology itself that is like reality but is not real, created by artificial technology.	Wohlgenannt Simons & Stieglitz, 2020 [12]
Mirror Worlds	It is a representation of the real world in digital form. It attempts to map real-world structures in a geographically accurate way. It offers a utilitarian software model of real environments and their workings.	Che & Lin & Hu, 2011 [13]

Metaverse is a new paradigm that will replace the post-internet era, and it is being defined in various ways by various researchers and organizations. In the metaverse, as defined by the ASF (2007), the concept of "convergence of a virtually enhanced physical reality and a physically permanent virtual space" is accepted as the most common. In addition, it is defined as "a 3-dimensional (3D) virtual space where social and economic activities like the real world are used”, or “a new world and digitized earth contained in digital media such as smartphones, computers, and the Internet that cannot be limited to the virtual world” [14]. Other scholars define the metaverse as “a 3D-based virtual world in which daily activities and economic life are conducted through an avatar representing me in the real life”, and “the virtual and reality interact” [15]. It is also defined as a world in which social, economic, and cultural activities take place in an advancing world, creating value [16].

In Figure 1, a quadrant-based metaverse type is introduced; the horizontal axis represents the relationship between “Technology” and “User”, and the vertical axis represents the relationship between “Technology” and “Reality” [9].

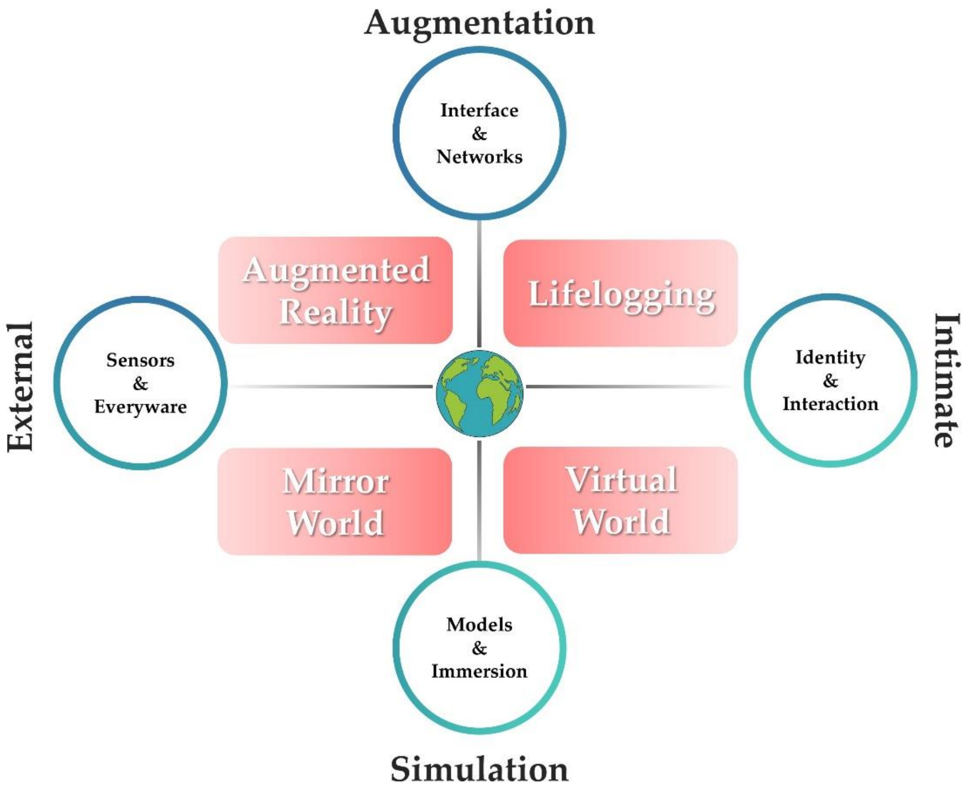

Figure 1. Four Types of Metaverses.

The horizontal axis is a standard that shows the degree to which the external environment is reflected, and of user immersion intensification (intimate), as shown in Figure 1. On the other hand, the vertical axis shows a criterion for distinguishing between the augmentation of reality, which is a space in which information is implemented, and simulation in the virtual world. According to this standard, the horizontal axis is divided into external and intimate elements, and the vertical axis is divided into augmentation and simulation. That is, it can be classified into four categories: augmented reality, lifelogging, mirror worlds, and virtual worlds.

3. Physical Education in a Metaverse Environment

In the current physical education field, interest in and demand for teaching and learning activities based on virtual reality or augumented reality have been increasing, and are currently being developed [11,12]. Among metaverse technologies, virtual reality education has achieved considerable publicity via the installing and supporting of “virtual reality sports classrooms” in several schools by the Ministry of Culture, Sports and Tourism of Korea two to three years ago. In addition, sports games using augmented reality—for example, screen golf, tennis, baseball, table tennis, yoga, dance, etc.—can be used as a means of instruction in physical education activities. On the other hand, the lifelogging method records and manages physiological changes in the human body using a smart watch; wheras the mirror world is a model in which, for example, several people are riding bicycles together on one screen.

Based on this, metaverse physical education classes are being practiced using artificial intelligence (golf, table tennis, e-sports), and are also exploiting the internet of mole (soccer, football, yachting) and big data (baseball, outdoors, basketball) [17]. In particular, the practice is spreading to physical education via virtual and augmented reality (basketball, skiing, surfing, rafting, etc.) and cloud subjects (F1, American football, baseball, e-sports). Case studies using mobiles (smart stadiums, mobile games) and the blockchain (living sports platforms, game prediction, sports media, etc.) have also been reported [18,19]. Table 2 shows the current level of technological development using the metaverse across the world [20,21].

Table 2. The functions, necessary tools, and examples according to four metaverse types.

Classifications	Definitions	Examples
Augmented Reality	Sports activity that creates unreal information by superimposing virtual objects or interfaces on the physical environment recognized by the user.	Hwang & Chien, 2022 [17]
Lifelogging	Sports activities in a virtual space that allow users to record body information, emotions, and behaviors directly or through a device.	Egliston & Carter, 2021 [18]
Virtual Reality	A virtual sports world that expands real sports activities and similarly builds alternative virtual models.	Hwang & Chien, 2022 [17]
Mirror World	A blended technology that realistically reproduces the physical world but expands that information into the sports world.	Jeong & Yi & Kim, 2022 [19]

For metaverse technology to be used effectively, a knowledge information delivery system in the internet environment must be in place, and information technology capabilities such as artificial satellite information networks must be developed beyond 5G or higher networks. In addition, devices that can show virtual reality comparable to actual reality must be developed. The advantages of augmented reality, lifelogging, and virtual reality are that they can be used even in a small space, knowledge can be shared quickly between instructors and learners, and costs can be low, because there is no intermediate margin such as distribution or transportation. The advantages of the mirror world are similar to those of the above three metaverse types, but here, the capacity for knowledge sharing between the instructor and the learner is unknown. The disadvantages of augmented reality, lifelogging, and virtual reality are that the purchase cost of the device is high, and the technical part is not easy to understand. On the other hand, in addition to these disadvantages, the mirror world also presents the disadvantage that it can only operate optimally when a computerized information network of 5G or higher is established.

Virtual reality technology related to physical education has already been successful in VR boxing, VR tennis, and VR table tennis. In addition, augmented reality technologies such as screen golf, screen tennis, and screen baseball can be used as physical education curriculums. In particular, among metaverse technologies, lifelogging can be widely used in exercise physiology and training fields; while the mirror world also allows a professor and a large number of students to ride bicycles together and teach correct exercise methods on one screen. Figure 2 shows examples of augmented reality, lifelogging, mirror worlds, and virtual worlds within the physical education context, assessed according to the metaverse standards.

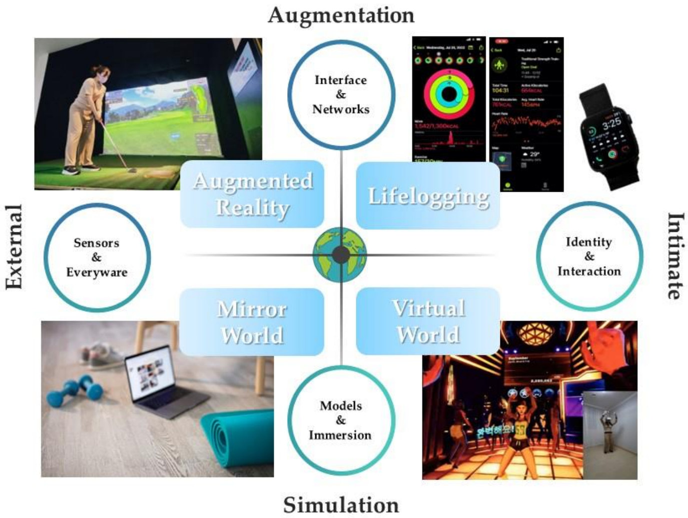

Figure 2. Four Types of Physical Education Areas of the Metaverse.

4. Practical Classes of Physical Education by Metaverse Types

4.1. Augmented Reality and Physical Education Practice

Augmented reality is a technology that enhances work efficiency by augmenting virtual information in real time and space [10,22]. It allows learners to interact with the augmented virtual information, as shown in Figure 3.

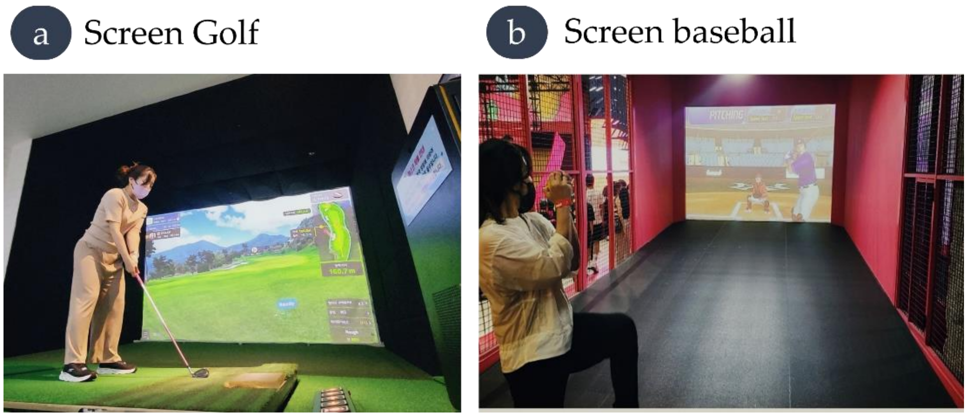

Figure 3. Practical physical education in augmented reality.

Screen golf (Figure 3a) is a game in which a ball that remains on the 18th hole is hit with a golf club into each hole, just like in real golf. In a real golf game, the ball is hit with the golf club from the 1st to the 18th hole. The person who hits the ball the lowest number of times is the winner. A normal golf course is about 6–7 km long and takes 3–4 h to walk, but screen golf takes about 1–2 h per person, because there is no walking distance. Like in a real golf course, screen golf, with a total of 18 holes, consists of 9 out-course holes and 9 in-course holes. There are two par 3 holes (short holes), five par 4 holes (middle holes), and two par 5 holes (long holes) for every nine holes in the first half and second half. The standard number of strokes is 72 strokes when 18 holes are used. If a learner scores three less than the number of holes, this is called an "Albatross"; two less than the number of holes is an "Eagle"; one less than the number of holes is a "Birdie"; and if their score is equal to the standard number of holes, it is a "par". On the other hand, a score of one over the number of holes is called a "Bogey", two over is called a "Double bogey", three over is a "Triple bogey", and four over is called a "Quadruple bogey". In Korea, due to the availability of screen golf, golf is becoming very popular, and its use is expected to be very high in physical education.

4.2. Lifelogging and Physical Education

A typical example of lifelogging is a smart watch. The smart watches released to date usually function independently or as a peripheral device linked to a smartphone. Since this device is in the shape of a wristwatch, the screen size is limited, so the input/output environment is limited. However, as it is wearable and carried in close contact with the wrist, the physiological information of the human body (heart rate, blood pressure, metabolic consumption, body temperature, electrocardiogram and so on) is always acceptable [11]. It is also possible to send a signal to the user as a haptic output through tactile senses such as vibration. In addition, since it is fixed on the wrist, the smart watch's information can be read without using any hands, compared to smartphones that require at least one hand to use. However, since humans are highly dependent on visual information, it is a general assessment that the weaknesses outweigh the strengths, and that it will be widely usable as a fully fledged smart device only if there is a breakthrough in user-interface development, or a change in idea. Lifelogging is a method of augmenting the inner world [23]. In the world of lifelogging, many learners use smart devices to record their daily lives on the internet or on smartphones, as shown in Figure 4.

Figure 4. Practical physical education in lifelogging.

A culture of analyzing, recording, organizing, storing, and sharing information on lifestyles through various forms of data generated from daily activities is currently spreading. This daily digitization has the advantages of productivity, flexibility, relationship orientation, and customization [24]. As shown in Figure 4b, Nike+ is a representative example of a lifelogging technology applied to enable daily exercise. Nike+ is used to motivate running and achieve goals by measuring and recording the distance, time, and calories burned through the Nike+ sensor attached to the sneaker. In addition, the Nike+ running technology allows users to share their routes and records with other users [14]. In addition, Nike+ has developed a run club, providing running courses and customized running programs.

Introducing augmented reality technology, the wearing of goggle-like glasses offers a virtual partner, such as a "Ghostpacer" that runs with the learner [25]. This can be used as a very effective exercise tool to continuously practice exercise, or control exercise intensity. It can be used to introduce a virtual partner to suit the learner's condition and adjust their records, increasing motivation with the same effect as running with another person.

4.3. Virtual Reality and Physical Education

The virtual world is a type of simulation of the internal world. It uses virtual reality technology, which includes sophisticated 3D graphics, avatars, and instant communication tools, so that learners feel that they are completely immersed in a virtual world. In the post-coronavirus crisis period, Korea is trying to cope with continuing outdoor sports activities using virtual reality technology to avoid the effects of fine dust and bad weather. The virtual reality technology is a virtual reality system that allows sports activities to be performed while watching a screen, such as with screen golf in the classroom. In a situation where sports activities cannot be performed due to restrictions on outdoor activities, most learners can still enjoy sports activities within virtual reality just as they would actually play soccer or baseball. Virtual reality sports are sports that allow users to experience the effects of real exercise within an augmented reality system in a virtual world. As described above, screen golf, baseball, tennis, badminton, table tennis, horseback riding, and yoga (shown in Figure 5) may be taught in the same way as in actual physical education practice.

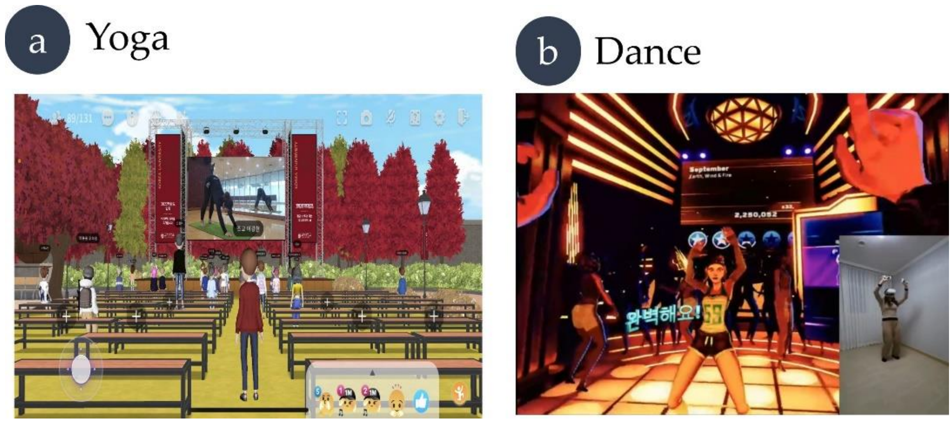

Figure 5. Practical physical education in virtual reality.

4.4. Mirror Reality and Physical Education

The mirror world is a type of simulation of the external world, and refers to informationally enhanced virtual models or reflections of the real world [15,16]. The mirror world is a metaverse that transfers the appearance, information, and structure of the real world to a virtual world, as shown in Figure 6.

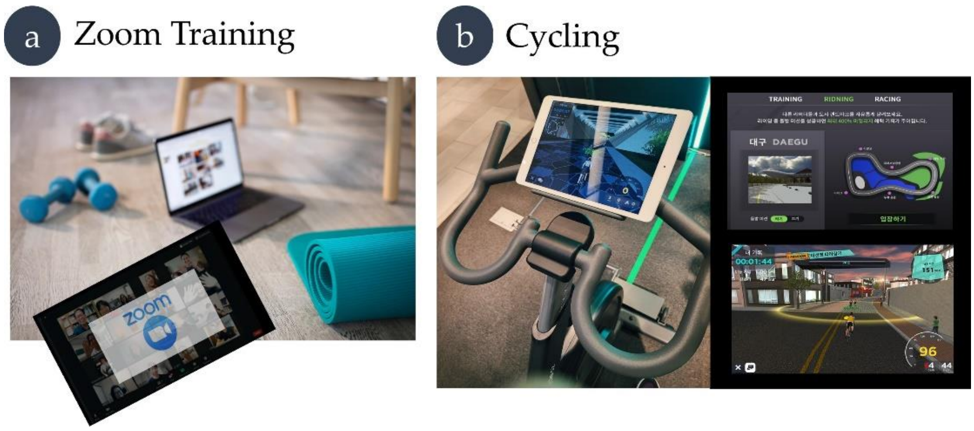

Figure 6. Practical physical education in the mirror world.

Rather than being the same as reality, it is as an efficient expansion of reality [20]. The mirror world is made possible by lifelogging technologies such as mapping, modeling and geospatial tools and sensors, and location recognition technology that connects real and virtual spaces. Map information based on GPS, various data extracted from the real world, and mapping technologies that connect them make the mirror world possible. Most of the technologies corresponding to the mirror world are linked with maps such as Google Maps and Naver Maps [14]. A learner can also search for the nearest exercise facility, check its location, and make a reservation. In addition, they can prepare in advance as if they had already visited the desired place.

The mirror world, which is being used in various fields in society and industry as a result of recently developed technology, serves as a medium that makes it easy for humans to accept their avatar in the metaverse as a familiar and comfortable personality, without any sense of alienation. Therefore, it can be easily used in a singular curriculum in the field of physical education.

5. Discussion

This study was initiated to explore whether the four metaverse technologies can be applied as a physical education curriculum. At this early stage, many metaverse technologies related to the field of physical education are already being used in the game industry and real life (smart watch, screen golf, etc.). The early metaverse was intended for consumption-oriented economic activities such as the trading of items provided by service providers. Currently, metaverse technology use is evolving in the direction of increasing the connection between production and consumption in the real economy, such as when users develop and produce games and items. This is true not only in the education field, but also in the field of physical education, where practical skills must be emphasized. The technological types of the metaverse have been developed independently so far [26], and it seems that each type is gradually breaking down boundaries and evolving into a new type of service, rather than them being clearly separated. Moreover, a new environment for the visualization of information in the virtual world can interact in real time with the real world [27].

Highlighting the trend toward big data, artificial intelligence, blockchain and other digital technologies becoming a multi-agent collaboration, one study noted a top-level design was further developed by the government, a resource allocation optimized by enterprise, and safety awareness raised at the individual level [28]. Thomason (2021) suggested that metaverse technology will change health care methods in the future, and furthermore will lead to collaborative working and education; as well as in clinical care, wellness, and monetization [29]. These developments are attracting attention as the metaverse is increasingly used for education and commercial use. Virtual reality, augmented reality, the mirror world, and mirror reality are being comprehensively fused with technologies such as big data, artificial intelligence, and 5G networks; and "extended reality" is emerging.

To smoothly undertake physical education classes in a non-face-to-face environment such as the metaverse, many aspects still have to be resolved. To make this a reality, physical education teachers need to develop professional education skills that can utilize Edu+tech [30,31]. An online role-playing game, which is an example of a metaverse technique, can also be used in an educational environment [32,33]. According to the results of a study using this technique, the learning achievements and educational satisfaction of the students who took part in the online role-playing game were higher than those of the students who took the face-to-face class. Educational satisfaction and academic achievements in the metaverse environment were analyzed by prior knowledge, learning motivation, and network environment [34,35]. A research report further stated that the immersiveness and effectiveness of learning can be increased through the presence of content, which is the core of virtual reality technology. Moreover, more opportunities may arise to design physical education classes using the metaverse platform, such as 'in "Gather Town", and share the information obtained or provided through repeated case studies [36]. These studies will make it possible to improve learners' immersion in the task through realistic physical education experiences, and they can be expected to improve the usefulness of learning and educational satisfaction, as well as interest in the class. Meanwhile, the effectiveness of motor learning for students after physical education class using the metaverse needs to be explored. Moreover, students' physical activity levels after metaverse physical activity should be evaluated. In the future, metaverse technology will further evolve and advance into automation technology. In response, one study concludes that the success of AI in various fields and development of information technology will lead to the convergence of the sports industry and AI. In particular, the authors reported that traditional physical education is currently undergoing qualitative changes, and the demands to incorporate artificial intelligence and the metaverse into physical education are becoming more and more evident [37]. In any case, in order for the latest metaverse technology and future AI technology to be combined and fully utilized in the field of physical education, appropriate professional development needs to be provided to teachers with all levels of experience in the education field [38].

After addressing the characteristics of the metaverse related to the physical education curriculum, the following can be concluded. First, the possibility of realizing the metaverse increases when not only the instructor and the designer, but also the learners, who are participants, have a worldview that has been created and is expanded together. In other words, in the space created by the instructor, the learner is an active user who independently consumes, produces, and spreads content, and they must become a user. Second, the metaverse should be able to expand itself by creating content for both instructors and learners. Third, the production of content and its consumption through digital currency must be developed within the metaverse. Fourth, as an extension of daily life, activity in the metaverse is not a one-time occurrence, but a continuous action, and users of the virtual world and the real world need to give and receive to influence the experience. Finally, virtual reality and the real world should be connected in the metaverse, and a link established between the instructor and the learner within the metaverse. That is, learners must transcend time and space to obtain information from the instructor through the metaverse, and the learner should provide the instructor with positive or negative feedback on the content received in the metaverse. Only then will the metaverse be able to provide a sense of real existence and presence.

Augmentation systems create environments that make one feel as if one is playing a real game. They are designed so that athletes can train as if undertaking physical education classes in the classroom. They have made it possible to experience the pleasure, interest, emotion, and effect of actual exercise. On the other hand, an exploratory study on the development of metaverse sports room content concluded that physical education classes should develop content that is difficult to teach in the field of physical education. Recently, virtual reality sports room content has been evolving to advance human imagery ability and improve exercise performance [12,13,39]. In other words, virtual reality can be used to accelerate exercise ability, refine motor skills, and make the emotional satisfaction derived from interest and pleasure feel real. Sports in the metaverse have been developed by the sharing of feedback regarding situational judgments in real-world reality. In addition, the participants took part in the sport in virtual reality, with consideration of their previous practical experience, pleasure, interest, and emotion. Ultimately, physical education classes in the metaverse era will be developed while maintaining the "practice and practice"-centered online framework The roles of teachers at this point will have to change, from leaders and judges to collaborators and helpers. Furthermore, the role of the student should not be one-sided, but rather they should be seen as a leader who leads their own learning, immersing themselves in physical education classes and learning on their own.

6. Conclusions

Through this review paper, the following conclusions and suggestions have been derived for the use of the metaverse in physical education under the current situation. First, in the space created by the instructor in the metaverse, learners must become active users who independently consume, produce, and spread content. Second, instructors should be able to professionally produce and transmit physical education content to learners. Third, it is necessary to develop various content related to physical education. Fourth, it should be remembered that daily life in the metaverse is a continuous action, and users in the virtual world and real world must give and receive to influence outcomes. Fifth, a link must be established between the instructor and the learner in the metaverse. In relation to these five points, the metaverse environment is still in its developmental stage, and its use in physical education is only at the game level. In the future, physical education using metaverse technology will be possible in universities only when more specialized technology is incorporated into various sports. Ultimately, this paper will help expand the scope and depth of follow-up research, offering basic data showing the directions of development in metaverse-based physical education.

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References

1. Rothengatter, W.; Zhang, J.; Hayashi, Y.; Nosach, A.; Wang, K.; Oum, T.H. Pandemic waves and the time after COVID-19—Consequences for the transport sector. *Transp. Policy* **2021**, *110*, 225–237. [CrossRef] [PubMed]
2. Tlili, A.; Huang, R.; Shehata, B.; Liu, D.; Zhao, J.; Metwally, A.H.S.; Wang, H.; Denden, M.; Bozkurt, A.; Lee, L.H.; et al. Is Metaverse in education a blessing or a curse: A combined content and bibliometric analysis. *Smart Learn. Environ.* **2022**, *9*, 24. [CrossRef]
3. Yu, J.E.; Jee, Y.S. Analysis of online classes in physical education during the COVID-19 pandemic. *Educ. Sci.* **2021**, *11*, 3. [CrossRef]
4. Eswaramoorthi, V.; Kuan, G.; Abdullah, M.R.; Abdul Majeed, A.P.P.; Suppiah, P.K.; Musa, R.M. Design and Validation of a Virtual Physical Education and Sport Science-Related Course: A Learner's Engagement Approach. *Int. J. Environ. Res. Public Health* **2022**, *19*, 7636. [CrossRef]
5. Saleh, S.M.; Asi, Y.M.; Hamed, K.M. Effectiveness of integrating case studies in online and face-to-face instruction of pathophysiology: A comparative study. *Adv. Physiol. Educ.* **2013**, *37*, 201–206. [CrossRef]
6. Smart, K.L.; Cappel, J.J. Students' Perceptions of Online Learning: A Comparative Study. *J. Inf. Technol. Educ. Res.* **2006**, *5*, 201–219. Available online: https://www.learntechlib.org/p/111541/ (accessed on 1 January 2020). [CrossRef]
7. Jovanović, A.; Milosavljević, A. VoRtex Metaverse platform for gamified collaborative learning. *Electronics* **2022**, *11*, 317. [CrossRef]
8. Farjami, S.; Taguchi, R.; Nakahira, K.T.; Nunez Rattia, R.; Fukumura, Y.; Kanematsu, H. Multilingual problem based learning in metaverse. In *International Conference on Knowledge-Based and Intelligent Information and Engineering Systems*; Springer: Berlin/Heidelberg, Germany, 2011; pp. 499–509.
9. Smart, J.; Cascio, J.; Paffendorf, J.; Bridges, C.; Hummel, J.; Hursthouse, J.; Moss, R. A cross-industry public foresight project. In *Proc. Metaverse Roadmap Pathways 3DWeb*; Academia Press: Cambridge, MA, USA, 2007; pp. 1–28.
10. Kesim, M.; Ozarslan, Y. Augmented Reality in Education: Current Technologies and the Potential for Education. *Procedia—Soc. Behav. Sci.* **2012**, *47*, 297–302. [CrossRef]
11. Gurrin, C.; Smeaton, A.F.; Doherty, A.R. LifeLogging: Personal Big Data. *Found. Trends Inf. Retr.* **2014**, *8*, 1–125. [CrossRef]
12. Wohlgenannt, I.; Simons, A.; Stieglitz, S. Virtual Reality. *Bus. Inf. Syst. Eng.* **2020**, *62*, 455–461. [CrossRef]
13. Che, W.; Lin, H.; Hu, M. Reality-virtuality fusional campus environment: An online 3D platform based on OpenSimulator. *Geo-Spat. Inf. Sci.* **2011**, *14*, 144–149. [CrossRef]
14. Kye, B.; Han, N.; Kim, E.; Park, Y.; Jo, S. Educational applications of metaverse: Possibilities and limitations. *J. Educ. Eval. Health Prof.* **2021**, *18*, 32. [CrossRef] [PubMed]
15. Petrakou, A. Interacting through avatars: Virtual worlds as a context for online education. *Comput. Educ.* **2010**, *54*, 1020–1027. [CrossRef]
16. Zhang, X.; de Pablos, P.O.; Wang, X.; Wang, W.; Sun, Y.; She, J. Understanding the users' continuous adoption of 3D social virtual world in China: A comparative case study. *Comput. Hum. Behav.* **2014**, *35*, 578–585. [CrossRef]
17. Hwang, G.J.; Chien, S.Y. Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective. *Comput. Educ. Artif. Intell.* **2022**, *3*, 100082. [CrossRef]
18. Egliston, B.; Carter, M. Critical questions for Facebook's virtual reality: Data, power and the metaverse. *Internet Policy Rev.* **2021**, *10*, 1–23. [CrossRef]
19. Jeong, H.; Yi, Y.; Kim, D. An innovative e-commerce platform incorporating metaverse to live commerce. *Int. J. Innov. Comput. Inf. Control* **2022**, *18*, 221–229. [CrossRef]
20. Dwivedi, Y.K.; Hughes, L.; Baabdullah, A.M.; Ribeiro-Navarrete, S.; Giannakis, M.; Al-Debei, M.M.; Dennehy, D.; Metri, B.; Buhalis, D.; Cheung, C.M.K.; et al. Metaverse beyond the hype: Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *Int. J. Inf. Manag.* **2022**, *66*, 102542. [CrossRef]
21. Smart, J.; Cascio, J.; Paffendorf, J. *Metaverse Roadmap: Pathway to the 3D Web [Internet]*; Acceleration Studies Foundation: Ann Arbor, MI, USA, 2007. Available online: https://metaverseroadmap.org/MetaverseRoadmapOverview.pdf (accessed on 4 June 2008).
22. Bower, M.; Howe, C.; McCredie, N.; Robinson, A.; Grover, D. Augmented Reality in education: Cases, places and potentials. *Educ. Media Int.* **2014**, *51*, 1–15. [CrossRef]

23. Mozumder, M.A.I.; Sheeraz, M.M.; Athar, A.; Aich, S.; Kim, H.C. Overview: Technology roadmap of the future trend of metaverse based on IoT, blockchain, AI technique, and medical domain metaverse activity. In Proceedings of the 2022 24th International Conference on Advanced Communication Technology, Pyeongchang-gun, Korea, 13–16 February 2022; pp. 256–261.
24. Han, S.; Lim, C.I. Research trends on augmented reality education in Korea from 2008 to 2019. *J. Educ. Technol.* **2020**, *36*, 505–528. [CrossRef]
25. Huang, X.; Wild, F.; Whitelock, D. Design Dimensions for Holographic Intelligent Agents: A Comparative Analysis. In Proceedings of the 1st International Workshop on Multimodal Artificial Intelligence in-Education 2021, 14 June 2021. Available online: https://ceur-ws.org/Vol-2902/paper2.pdf (accessed on 8 July 2021).
26. Van Rigmenam, M. *Step into the Metaverse*; John Wiley & Sons, Inc.: Hoboken, NJ, USA, 2022.
27. Milgram, P.; Kishino, F. A taxonomy of mixed reality visual displays. *IEICE Trans. Inf. Syst.* **1994**, *77*, 1321–1329. Available online: https://www.researchgate.net/publication/231514051 (accessed on 25 December 1994).
28. Wu, J.; Gao, G. Edu-Metaverse: Internet Education Form with Fusion of Virtual and Reality. In Proceedings of the 2022 8th International Conference on Humanities and Social Science Research (ICHSSR 2022), Chongqing, China, 22–24 April 2022; Atlantis Press: Paris, France, 2022; pp. 1082–1085. [CrossRef]
29. Thomason, J. MetaHealth-How will the Metaverse Change Health Care? *J. Metaverse* **2021**, *1*, 13–16. Available online: https://dergipark.org.tr/en/pub/jmv/issue/67581/1051379 (accessed on 31 December 2021).
30. Weller, M. Twenty years of EdTech. *Educ. Rev. Online* **2018**, *53*, 34–48. Available online: https://er.educause.edu/articles/2018/7/twenty-years-of-edtech (accessed on 2 July 2018).
31. Sullivan, A.P.; Davis, G.A.; Stewart, J.C. Edtech effectiveness: Using screen casts to increase learning outcomes in information systems curricula. *Issues Inf. Syst.* **2018**, *19*, 39–53.
32. Suh, S.; Kim, S.W.; Kim, N.J. Effectiveness of MMORPG: Based Instruction in Elementary English Education in Korea. *J. Comput. Assist. Learn.* **2010**, *26*, 370–378. [CrossRef]
33. Delwiche, A. Massively multiplayer online games (MMOs) in the new media classroom. *J. Educ. Technol. Soc.* **2006**, *9*, 160–172. Available online: https://www.jstor.org/stable/jeductechsoci.9.3.160 (accessed on 3 July 2006).
34. Lee, A. Analysis of the Effectiveness of SOFTWARE LIBERAL EDUCATION in a Non-Face-To-Face Environment. *Northeast Asian Stud.* **2021**, *6*, 1–12. [CrossRef]
35. Lee, H.J.; Hwang, Y. Technology-Enhanced Education through VR-Making and Metaverse-Linking to Foster Teacher Readiness and Sustainable Learning. *Sustainability* **2022**, *14*, 4786. [CrossRef]
36. Gather. *Classroom in Gathertown [Internet]*; Gather: San Bruno, CA, USA, 2021. Available online: https://gather.town/ (accessed on 29 November 2021).
37. Li, H.; Cui, C.; Jiang, S. Strategy for improving the football teaching quality by AI and metaverse-empowered in mobile internet environment. *Wirel. Netw.* **2022**. [CrossRef]
38. MacCallum, K.; Parsons, D. Teacher perspectives on mobile augmented reality: The potential of metaverse for learning. In Proceedings of the World Conference on Mobile and Contextual Learning 2019, Delft, The Netherlands, 16–18 September 2019; pp. 21–28. Available online: https://www.learntechlib.org/p/210597/ (accessed on 16 September 2019).
39. Van der Geer, J.; Hanraads, J.A.J.; Lupton, R.A. The art of writing a scientific article. *J. Sci. Commun.* **2010**, *163*, 51–59. [CrossRef]