Use of Metaverse in Education

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Abstract. With the introduction of Metaverse, its use is increasing day by day. In this study, the factors affecting the historical development of Metaverse, the Metaverse architecture and the use of Metaverse in the field of education are discussed. The strengths and weaknesses of the use of Metaverse in the field of education are emphasized; the opportunities it will offer and the problems and threats that may be encountered are examined. Since Metaverse is a new concept, a resource for the use of Metaverse in the field of education has been tried to put forward by using the limited number of sources currently available in the literature. In this study, it is emphasized that the Metaverse environment can add a new dimension to the field of educational technologies. However, it should be taken into account that the necessary technologies and architectures in this field are not mature enough yet. Therefore, it is considered a necessity to determine appropriate strategies for the use of Metaverse in the educational field and to start determining its widespread effect until the infrastructure of Metaverse matures.

Keywords: e-learning · Educational technology · Metaverse · Metaverse in education

1 Introduction

Many historical steps have taken place from the centralized mainframe computers to the decentralized Metaverse environment that works connected to the Internet. In this section, the history of the Internet until the emergence of Metaverse is briefly summarized.

1.1 Web 1.0

The Web, later called Web 1.0, was introduced with the advent of the first browsers. It all started when Tim Berners-Lee wrote the first World Wide Web browser in 1990 by using a Next computer [1]. This was followed in 1992 by the Mosaic browser that was implemented by the National Center for Supercomputer Applications (NCSA) [2]. With Web 1.0, many individuals and institutions

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started to transfer their information to the web. Web 1.0, also referred as the business card web, attracted great attention, especially when it started to be used extensively by e-commerce companies. Many companies that used to sell remotely over the phone easily adapted to this situation and thus, the first seeds of a large e-commerce market were planted.

Web 1.0 was called the read-only web and consisted of static, read-only web pages shared by individuals or companies. Since the web pages were kept on the servers, the interaction between the users and the company websites was either asynchronous with the use of e-mail or synchronous via the telephone. In addition, although the search engines searching the web were very fast, they were far from giving the desired results. The structure of Web 1.0 can be shown as in Fig. 1. The guestbook presented in Fig. 1 is an Internet application with one-way communication where users can only send their comments.

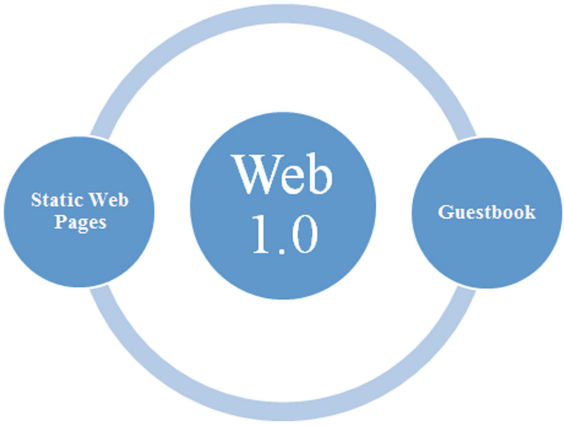

Fig. 1. Schematic illustration for Web 1.0

From an educational standpoint, like Web 1.0, e-learning was largely a one-way process during its early period. Students tried to learn through lecture notes, text-books, videos, animations and websites shared by their teachers [3,4].

1.2 Web 2.0

The concept of Web 2.0 was first introduced in 2004 in the web conference organized by Dale Dougherty, Tim O'Reilly and MediaLive International, in which the leading companies of the Web such as Google, Yahoo, MSN, Amazon, and EBay attended [5]. The Web 2.0 concept emerged during the discussions of the developments in the web field and the future of the web. Web 2.0 can be evaluated as an enhanced version of Web 1.0. With Web 2.0, users began to produce and share their own content. For this reason, Web 2.0 is also referred as a participatory social network [5]. The most important technologies in Web 2.0 systems

are AJAX and JavaScript. The most important components in the booming of Web 2.0 were mobile devices and social media. Especially, with the use of social media tools as applications on mobile devices, large user groups have started to see social media as a sharing platform. The Social Web includes a set of online tools and platforms where people can share their perspectives, thoughts, views and experiences. Web 2.0 applications are developed with much more interaction possibilities with the end users than traditional applications. Therefore, the end users are not only the users but also the participants of the application. The most widely used Web 2.0 tools can be grouped as podcasting, blogging, tagging, curating with RSS, social bookmarking, social networking, social media, and web content voting. The structure of Web 2.0 and its relationship with Web 1.0 is shown in Fig. 2.

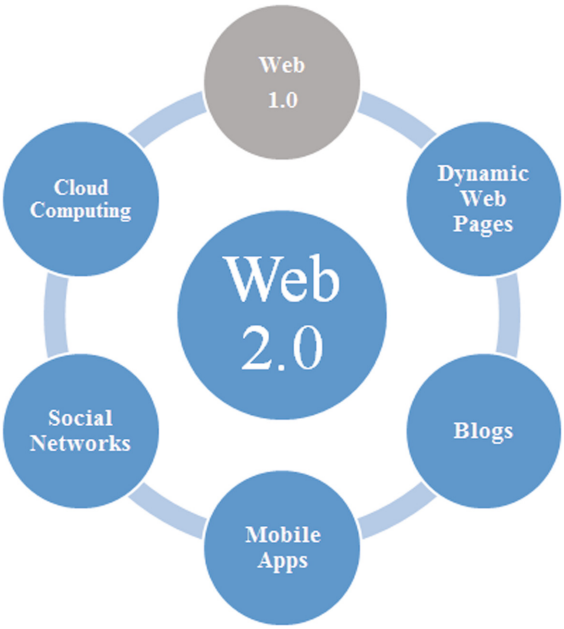

Fig. 2. Schematic illustration for Web 2.0

Web 2.0 technologies and especially social networking sites like MySpace and Facebook, affect the lives of millions of students in a powerful way. Researchers investigated the extent of this effect in various studies, and they agree that social networks should be included in education if it is to have a significant impact [6]. The Horizon Report, prepared by the New Media Consortium and EDUCAUSE in 2008, points out that it is necessary to develop strategies to take advantage of social networks for educational purposes [7].

1.3 Web 3.0

Web 3.0, defined as the future of the Internet, is also known as the read, write and run web [8]. Web 3.0 is also named as the Semantic Web by Tim Berners-Lee, and is designed as a more autonomous, intelligent and open Internet [9]. However, it is anticipated that a new definition will be needed, especially with the development of artificial intelligence, wearable technologies, Internet of Things technologies and 5G communication technologies. In addition, technologies such as decentralized blockchain, NFTs (Non-Fungible Tokens) and AR (Augmented Reality) Cloud that have emerged in the last few years also mean a move towards decentralization of data and a transparent, secure Internet. The schematic representation of Web 3.0 and its relationship with its predecessors Web 1.0 and Web 2.0 is shown in Fig. 3.

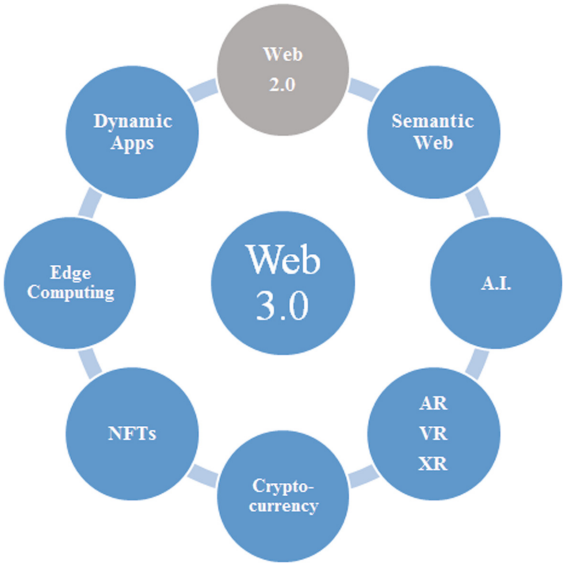

Fig. 3. Schematic illustration for Web 3.0

The following results were obtained by [10] on the effects of Web 3.0 technologies on education: with social semantic networks, openness and interoperability processes, the diversity of information will increase, so learning will take place at a more effective level. With technologies such as big data, linked data, cloud computing and mobile computing, information resources in the learning process will be connected, thus the connections in the relevant learning area will also improve [11]. Thanks to artificial intelligence, machine learning and 3D environments, learning will be more permanent.

2 Metaverse Environment

One of the environments that is built on Web 3.0 technologies and covers all Web 3.0 technologies emerges as Metaverse (Fig. 4). Although there are many different definitions, if a comprehensive definition is required, Metaverse can be defined as worlds in the digital environment where you have a digital copy and can perform some actions using recent technologies [12–14]. Here, the digital copy can be your digital twin made by preserving your physical features, or an avatar designed by you.

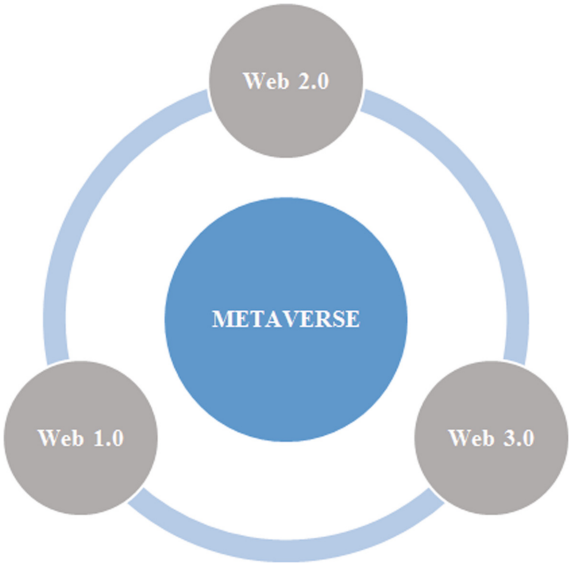

Fig. 4. Metaverse structure supported by Web 1.0, Web 2.0 and Web 3.0

The concept of Metaverse is one of the concepts that have become popular recently. The trend graph of this concept is presented in Fig. 5.

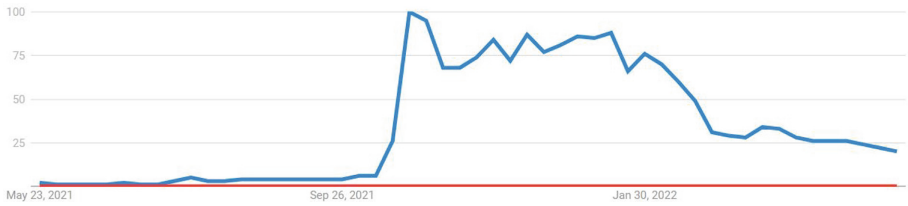

Fig. 5. Google trend of the word "Metaverse" worldwide [15]

Looking at the last year's Google trends, it is seen that the concept of Metaverse was searched a little before, but it peaked after November 2021 and its popularity decreased over time (Fig. 5). It is observed that the top 5 countries contributing to these trends by searching on Google are Turkey, China, Singapore, Cyprus and Hong Kong [15].

3 Metaverse Architecture

Metaverse architecture consists of seven proposed layers [16]. These layers are shown in Fig. 6 and can be listed as infrastructure, human interface, decentralization, spatial computing, creator economy, discovery, and experience. Although the proposed layered structure has not been fully tested yet, the subject of which layers will work best in the coming years will be a separate research infrastructure.

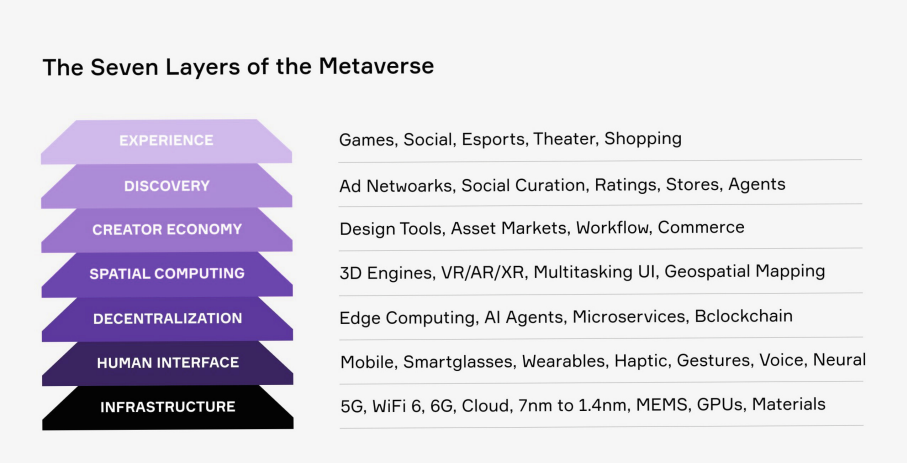

Fig. 6. Seven layers of Metaverse [16]

The seven layers of Metaverse can be briefly explained as follows, starting from the innermost.

– Infrastructure: It emerges as the physical layer on which the entire Metaverse structure is placed. Here, the Internet bandwidth is increased with the 5G and 6G communication technologies, the delays are reduced, the size of the mobile devices is reduced and the battery life is increased with the development of semiconductor technology, and the sensors are transformed into a more sensitive and smaller form with microelectromechanical systems (MEMS).

- Human Interface: As semiconductor manufacturing technologies are getting closer to support design structures approaching 3 nm, the produced hardware will be used more frequently in and on the human body. Thus, with the use of biosensors and neural interfaces, the sense of touch and feeling will be activated in addition to the senses of sight and hearing. With the support of haptic technologies, it will be possible to control devices without any physical interface.
- Decentralization: It is one of the most important features of Metaverse. Metaverse is designed for users and content producers to own the system, and it is anticipated that it will not develop under the leadership of any company or institution. In particular, edge computing and blockchain technologies will provide significant support in this direction.
- Spatial Computing: The environment that comes to mind for many people about Metaverse is the 3D environment. However, Metaverse offers more than just a 3D environment. Objects can be digitized by using spatial computing and combining virtual/augmented/extended reality (VR/AR/XR), sensors can be developed to react with motors, and the physical world can be digitized by utilizing spatial mapping.
- Creator Economy: In the earlier versions of the Internet, creators were required to have at least some degree of programming knowledge in order to design and build tools, applications or asset markets. Nowadays, it is possible to develop web applications without coding thanks to web application frameworks. As a result of this, the number of content creators and designers on the web is growing exponentially. It is expected that anyone will be able to be create web contents in the near future without even learning how to program. The increase in the number of web content creators is a defining component of the Web 3.0 economy, which can be referred as the age of content creators.
- Discovery: It is the layer which introduces users to brand new experiences on Metaverse. With the widespread use of Metaverse, assets in this layer will be able to be marketed and advertised by companies. In Metaverse environment, where information sharing is very important, users will be able to create their own content and freely publish it to communities. Nowadays, the most important example of this experience is observed as NFTs.
- Experience: It is the most emphasized layer of Metaverse. With this layer, it is thought that people can have different and new experiences (such as multi-user games, shopping, etc.). The most important of these experiences will be live events (such as concerts, fairs, trainings, excursions, etc.). In this way, Metaverse users will be able to access events that they may never be able to access in real life.

4 A Brief History of Metaverse

Although the concept of Metaverse became popular in October 2021, when Mark Zuckerberg announced that Facebook would change its name to Meta [17] and

make significant investments in Metaverse, it is not a new concept. In their extensive work on Metaverse, Lee et al. [18, p. 4] take the history of Metaverse back to the book/game Dungeons & Dragons published in 1974. Then, Neuromancer, a cyber frenzy science fiction novel by William Gibson, which was released in 1984, is considered as another critical milestone for the development of Metaverse. The novel Neuromancer has also been the subject of films such as The Matrix and Ghost [19]. The word Metaverse was first used in 1992 in the science fiction novel Snow Crash which was written by Neal Stephenson [20].

The years between 1992 and 2016 are referred as the period of virtual worlds and multiplayer online gaming platforms. Some of the milestones for multiplayer virtual world concept can be expressed as Active World released in 1995, Online Traveler realized in 1996, Second Life launched in 2003 and Minecraft launched in 2011. Pokemen Go, which was released in 2016, VR Chat, which was released in 2017, Super Mario AR, which appeared in the same year, CryptoKitties in 2017 and Alien Worlds in 2020 can be listed as more recent cornerstones of this period. The announcement of Facebook founder Mark Zuckerberg in 2021 that Facebook would change its name to Meta [17], and South Korea's statement that it would make Metaverse a state policy, and sharing of important strategic plans and policies in this direction with the public [21,22] clearly reveals why a new era has begun for Metaverse structure. The movie Ready Player One (released in 2018) was adapted from the 2011 novel of the same name by Ernest Cline. The movie is about people who are bored with their lives in cities, and spend a lot of time in the virtual world called OASIS by using their avatars in 2045 [23].

5 Use of Metaverse in Education

When academic studies scanned in Web of Science and Scopus databases were searched using the word "Metaverse", 128 publications have been identified. However, only 7 of these publications are related to the field of education. Common publications in both databases are counted only once in the Web of Science database. 5 studies and 2 studies are detected in the Web of Science and Scopus databases, respectively [24,25]. Brief summaries of these pioneering publications are detailed below:

In a study which was conducted to determine how closely Metaverse is related to the daily lives of primary school students, it was aimed to analyze Metaverse experiences and attitudes of students in a student-centered education setting by using a constructivist perspective [26]. This study also examines how students become the focus of new educational technologies. A survey was conducted with 336 primary school students in Korea by using 18 items to measure different factors of actions performed in Metaverse (such as studying, attending class, playing games, etc.). Then, statistical analyzes, including the difference of means and an independent sample t-test, were performed. The findings showed that 97.9% of primary school students have experience with Metaverse and 95.5% consider it closely related to their daily lives [26].

A system that utilizes virtual reality and Metaverse in a classroom setting is proposed by [27] to overcome the limitations and deficiencies of the existing

distance applied education methods. An aircraft maintenance simulation was developed based on the VR and Metaverse oriented approach and an experiment was conducted to compare the proposed system with a traditional video training based approach. In order to measure the effectiveness of both approaches, knowledge acquisition and retention tests were applied. The findings of the experiment revealed that the group that followed the VR and Metaverse oriented approach scored higher on both knowledge tests than the group that followed the video training based approach. Besides, the answers to the questionnaires indicated that the participants felt a sense of spatial presence, and it was concluded that the usability of the proposed approach was higher than the video training based approach [27].

In a study conducted in dentistry education, [28] presents different ways to use virtual environments that simulate operating room environments and focuses on teaching students various stages of surgeries. The use of different scenarios during the training of dentists provides a crucial advantage on their education.

The study proposed by [29] introduces a training course in Metaverse that was held in Korea and illustrates the prospects for how this technology can be used in the medical field in the future with a lung cancer surgery example. The utilization of different surgery scenarios and different solutions by using of the information about the patients registered in the hospital databases plays an important role in increasing the knowledge levels of students.

It is emphasized by [30] that providing interaction between participants in virtual worlds with Metaverse technology can also be valuable in language education. This study examines the application examples of Metaverse technology in Korean language education and presents a classroom model for task-based teaching methods. Consequently, it is anticipated that this will be used as data to guide Metaverse-based Korean language education [30].

It is shown in [31] that VR production experience for developing instructional content is conducive to improving pre-service teachers' technological preparation, critical thinking, creativity, collaboration, communication and pedagogical perception on digital citizenship. Findings of this study show that such studies can be used for sustainable education.

In a study based on developing measurement tools, [32] determined that the main variables affecting confidence in the future use of Metaverse in education are the lack of understanding of Metaverse, the lack of belief in the current technology, and the lack of awareness about the application of Metaverse in education. As a result of this study, it was concluded that the dissemination of the current technological level and the current speed of technological development can significantly increase people's trust in Metaverse.

6 Advantages and Disadvantages of Using Metaverse in Education

As every new technology gets used in education after a while, 3D virtual worlds, which were used mostly for games and entertainment before Metaverse, were also

used in education [33]. Bringing education together with entertainment makes educational environments more attractive and this way more active participation of learners can be achieved [34]. Therefore, Metaverse has started to be used in educational processes as a 3D virtual environment. However, it is gradually emerging that the concept of Metaverse has some problems and limitations as well.

Based on the limited number of resources available for Metaverse, the advantages of using Metaverse in educational environments can be explained as follows:

- By providing realistic and rich educational experiences for learning, it facilitates the relationship between the real world and the virtual world for learning by doing and living [28,30,31].
- It enables the acquisition, sharing and discussion of information provided by visual, audio and touching inputs [27,29,30].
- By appealing to students' visual, auditory and tactile senses, it can contribute greatly to the realization of concrete learning which is one of the most desired functions in teaching environments [28,29,31].
- By providing access to students from different geographies, it enables students to study in the same environment [30].
- By enabling the engagement with time-consuming, difficult, risky, and complex learning experiences in real life, it facilitates learning in these areas [27–29].
- For skill-based learning, it provides the opportunity to practice different skill types and repeat these practices as much as desired [28,29].
- It helps to eliminate the problems experienced in collaborative working due to disability, time, cost, physical distance and geographical limitations [28].
- It enables learners to socialize with their gestures, mimics and movements, by establishing multi-channel communication in written, oral and both written and oral forms, and thus, facilitates social learning [30].
- By developing serious game and gamification opportunities in Metaverse, it provides a fun learning environment [26].

Besides the positive contributions that Metaverse can bring to learning environments, there are also negative aspects [35–37]. These are presented below:

- It is necessary to analyze the knowledge levels of the learning stakeholders on Metaverse and their the beliefs about the use of Metaverse in education, and to eliminate the lack of knowledge and misunderstandings [32].
- From a technical point of view, developing Metaverse environments is a time-consuming, expensive and extensive process. When examined from this aspect, a large team of pedagogues, teachers, 3D designers, software developers, and graphic designers should work together in harmony.
- Instead of completing the learning tasks assigned to them, the learners using Metaverse may start to spend time with more fun and interesting elements and the problem of time wasting may arise.
- Problems may arise regarding learners' level of knowledge on information technologies, especially due to lack of computer usage knowledge and intrinsic motivation.

- Problems related to cultural and social differences may arise in the socialization and cooperation processes of learners from different cultures and geographies using Metaverse.
- Ethical problems such as using slang expressions, insulting, bullying and humiliating each other may occur in the communication between learners. In addition, it seems likely that companies in Metaverse may experience ethical problems with each other and with learners.
- Learners using poorly designed Metaverse interfaces may experience usability and accessibility problems, and additionally, the cognitive load of the learners may increase due to the limitations caused by inadequate interface designs.

In addition to the items mentioned above, it is possible to add new items that may indirectly affect the limitations of Metaverse in the field of education. These are listed below:

- Since Metaverse is a new concept, Metaverse environment is currently followed as an anomalous environment. There are no national or international legal regulations in this area. As a result, it is necessary to make legal arrangements for this situation, which may be of interest to both national and international educational communities.
- Since Metaverse environment is a decentralized Internet environment, it seems weak in terms of computer security. In particular, some or all of Metaverse can be neutralized, for example, by DDOS attacks [36,38].
- In order to use Metaverse (also chat software, virtual reality, computer games, mobile applications, and social media) in the field of education, especially teachers and parents should approach very carefully and be cautious.
- Because, especially young children and adolescents moving away from reality and staying in Metaverse with content that will only make them happy, will negatively affect their mental state [39].

7 Conclusion

With its intriguing, interesting and entertaining features, Metaverse environment will have many contributions to distance education, learning by doing and experiencing, educational simulations, social learning environments, and guided and unguided learning processes. In addition, it is clear that new opportunities can be provided to learners with disabilities and/or those who have problems in accessing learning resources, in terms of providing equal opportunities in education with Metaverse environment where physical boundaries have been removed.

However, the use of every new technology in education may cause some problems in terms of instructional technologies. In particular, there are some problems such as how to make effective instructional designs for Metaverse environment, how the learning will take place, how to conduct effective assessment and evaluation studies in this field. It does not seem possible to achieve effective learning by using the opportunities provided by Metaverse environment with classical

learning approaches. Therefore, a new pedagogy, which can be called Metaverse pedagogy, needs to be introduced.

Since Metaverse is a new technology body, this technological structure needs to be accepted by learners, instructors, school administrators and all stakeholders involved in teaching. Factors such as psychological and social norms and cultural differences will affect the acceptance process of Metaverse technologies. Therefore, it is necessary to approach the use of Metaverse carefully in learning processes.

Since Metaverse is a new concept, its components and architecture have not been fully realized and adopted yet. Since it is not certain exactly which levels of the architecture will be accepted in the coming years, it is open to radical changes. Therefore, it is necessary not to rush to move learning environments to Metaverse.

The design and full implementation of Metaverse will be an extensive process that will take a long time. Therefore, before moving the learning environments to Metaverse, it should be analyzed in sufficient detail whether the use of Metaverse for learning purposes is appropriate for the learning to be carried out.

The most important feature of Metaverse is the experience offered in the top layer of its architecture. However, in order to be able to live and let live this experience fully and satisfactorily in learning environments, the equipment that will involve the sense organs in the process will need to be more usable and cheaper. The development and widespread use of these hardware will take time.

In order for Metaverse to take place effectively in learning environments and to use the resources allocated for it correctly, national and international collaborations should be developed. In this regard, academic and non-academic stakeholders need to come together and carefully plan the process in order to produce the necessary hardware, software, content and human resources.

References

1. Berners-Lee, T.: The WorldWideWeb browser. https://www.w3.org/People/Berners-Lee/WorldWideWeb.html. Accessed 19 Apr 2022
2. Stewart, W.: Mosaic - The First Global Web Browser. http://www.livinginternet.com/w/wi_mosaic.htm. Accessed 19 Apr 2022
3. Ciloglugil, B., Inceoglu, M.M.: Exploring the state of the art in adaptive distributed learning environments. In: Taniar, D., Gervasi, O., Murgante, B., Pardede, E., Apduhan, B.O. (eds.) ICCSA 2010. LNCS, vol. 6017, pp. 556–569. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-12165-4_44
4. Ciloglugil, B., Inceoglu, M.M.: User modeling for adaptive e-learning systems. In: Murgante, B., et al. (eds.) ICCSA 2012. LNCS, vol. 7335, pp. 550–561. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-31137-6_42
5. Morkoç, D.K., Erdönmez, C.: Web 2.0 Uygulamalarının Eğitim Süreçlerine Etkisi: Çanakkale Sosyal Bilimler Meslek Yüksekokul Örneği. AJIT-e Online Acad. J. Inform. Technol. **5**(15) (2014) https://doi.org/10.5824/1309-1581.2014.2.002.x
6. Perikos, I., Grivokostopoulou, F., Kovas, K., Hatzilygeroudis, I.: Utilizing social networks and Web 2.0 technologies in education. In: 2015 IEEE Seventh International Conference on Technology for Education (T4E), pp. 118–119 (2015)

7. Genç Z.: Web 2.0 Yeniliklerinin Eğitimde Kullanımı: Bir Facebook Eğtim Uygulama Örneğ. In: XII. Akademik Bilişim Konferansı Bildirileri, Muğla, Türkiye, pp. 287–292 (2010)
8. What Is Web 3.0? The Future of the Internet. https://www.singlegrain.com/web3/web-3-0/. Accessed 22 May 2022
9. The 8 Defining Features of Web 3.0. https://www.expert.ai/blog/web-3-0/. Accessed 29 Apr 2022
10. Hussain, F.: E-Learning 3.0= E-Learning 2.0+ Web 3.0?. International Association for Development of the Information Society (2012)
11. Inceoglu, M.M., Ciloglugil, B.: Industry 4.0 briefcase: an innovative engineering outreach project for professions of the future. In: Gervasi, O., et al. (eds.) ICCSA 2020. LNCS, vol. 12250, pp. 979–988. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-58802-1_70
12. Newton, C.: Mark Zuckerberg is betting Facebook's future on the metaverse. https://www.theverge.com/22588022/mark-zuckerberg-facebook-ceo-metaverse-interview. Accessed 01 Apr 2022
13. Robertson, A.: What is the metaverse, and do I have to care?. https://www.theverge.com/22701104/metaverse-explained-fortnite-roblox-facebook-horizon. Accessed 01 Apr 2022
14. Clark, P.A.: What Is the Metaverse and Why Should I Care?. https://time.com/6116826/what-is-the-metaverse/. Accessed 01 Apr 2022
15. Google Trends. https://trends.google.com/trends/explore?q=metaverse. Accessed 19 Apr 2022
16. Radof J.: Building the Metaverse. https://medium.com/building-the-metaverse/building-the-metaverse-megadeck-7fc052cfe748. Accessed 01 Apr 2022
17. Nesbo, E.: The Metaverse vs. Virtual Reality: 6 Key Differences. https://www.makeuseof.com/metaverse-vs-virtualreality/. Accessed 01 Apr 2022
18. Lee, L.H., et al.: All one needs to know about metaverse: a complete survey on technological singularity, virtual ecosystem, and research agenda. arXiv preprint arXiv: 2110.05352 (2021)
19. Neuromancer. https://tr.wikipedia.org/wiki/Neuromancer. Accessed 01 Apr 2022
20. Joshua, J.: Information bodies: computational anxiety in Neal Stephenson's snow crash. Interdisciplinary Literary Stud. **19**(1), 17–47 (2017)
21. Kim, S.: South Korea's Approach to the Metaverse. https://thediplomat.com/2021/11/south-koreas-approach-to-the-metaverse/. Accessed 01 Apr 2022
22. Newar, B. South Korea embraces the proto-metaverse. https://cointelegraph.com/news/south-korea-embraces-theproto-metaverse. Accessed 01 Apr 2022
23. Ready Player One (2018). https://www.imdb.com/title/tt1677720/. Accessed 22 May 2022
24. WebofScience. https://www.webofscience.com/wos/woscc/summary/c22e6aa9-b7e9-420e-a536-3bd211f2da99-344e1878/relevance/1. Accessed 19 Apr 2022
25. Scopus. https://www.scopus.com/results/results.uri?sort=plf-f&src=s&st1=metaverse&st2=education&sid=45c88a66cddc8408444c0a7c29eb8c06&sot=b&sdt=b&sl=39&s=%28TITLE%28metaverse%29+AND+TITLE%28education%29%29&origin=searchbasic&editSaveSearch=&yearFrom=Before+1960&yearTo=Present. Accessed 11 May 2022
26. Suh, W., Ahn, S.: Utilizing the metaverse for learner-centered constructivist education in the post-pandemic era: an analysis of elementary school students. J. Intell. **10**(1) (2022). https://doi.org/10.3390/jintelligence10010017

27. Lee, H., Woo, D., Yu, S.: Virtual reality metaverse system supplementing remote education methods: based on aircraft maintenance simulation. Appl. Sci. **12**(5) (2022). https://doi.org/10.3390/app12052667
28. Locurcio, L.L.: Dental education in the metaverse. Br. Dent. J. **232**(4), 191 (2022)
29. Koo H.: Training in lung cancer surgery through the metaverse, including extended reality, in the smart operating room of Seoul National University Bundang Hospital, Korea. J. Educ. Eval. Health Prof. **18**, 33 (2021)
30. Park, J.: Exploring the possibility of using metaverse in Korean language education. J. Int. Netw. Korean Lang. Cult. **18**(3), 117–146 (2021)
31. Lee, H., Hwang, Y.: Technology-enhanced education through VR-making and metaverse-linking to foster teacher readiness and sustainable learning. Sustainability **14**(8), 4786 (2022)
32. Yue, K.: Breaking down the barrier between teachers and students by using metaverse technology in education: based on a survey and analysis of Shenzhen City, China. In: 2022 13th International Conference on E-Education, E-Business, E-Management, and E-Learning (IC4E), pp. 40–44, January 2022
33. Bulu, S.T.: Place presence, social presence, co-presence, and satisfaction in virtual worlds. Comput. Educ. **58**(1), 154–161 (2012)
34. Minocha, S., Reeves, A.J.: Design of learning spaces in 3D virtual worlds: an empirical investigation of second life. Learn. Media Technol. **35**(2), 111–137 (2010)
35. SWOT Analysis of the Metaverse for Businesses. https://quantilus.com/swot-analysis-of-the-metaverse-for-businesses/. Accessed 29 Apr 2022
36. The 7 Biggest Threats To Metaverse. https://discover.hubpages.com/technology/The-7-Biggest-Threats-To-Metaverse. Accessed 29 Apr 2022
37. Marr, B.: 7 Important Problems & Disadvantages of the Metaverse. https://bernardmarr.com/7-important-problems-disadvantages-of-the-metaverse/. Accessed 11 May 2022
38. Security Trends to Address Now, on Our Way to the Metaverse. https://www.akamai.com/blog/trends/security-trends-to-address-now-on-our-way-to-the-metaverse. Accessed 29 Apr 2022
39. Baltaş, A.: Metaverse'ün Hayatımıza Getirecekleri. https://www.acarbaltas.com/metaverseun-hayatimiza-getirecekleri-v/. Accessed 11 May 2022