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Metaverse: A Potential Virtual-Physical Ecosystem for Innovative Blended Education and Training

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***Abstract*— Recently online education has become quite popular, especially during the recent COVID-19 pandemic situations when mostly few remote synchronous S/W platforms were usually used across the globe. However, those platforms cannot replicate the physical classroom/training room environments and lack to provide hands-on support for laboratories or corporate development centers. Again, Metaverse has recently emerged as a useful platform for various types of useful applications. Metaverse has attracted the academic community for some time and this can be well utilized in education and training. Digital Twins (DT) can help in implementing the ideas and concepts of the natural/physical world in Metaverse-based education to make education more realistic and user-friendly. No work or literature review, to the best of the knowledge, of the author, is available that has considered the application of metaverse in training or developing skills for industry professionals along with academics in a holistic manner through an integrated environment. This paper aims to explore the potential of Metaverse for the development of an innovative virtual-physical blended teaching-learning. The objective is to overcome the limitations of current online and physical (offline) education and training systems of both academics and the corporate world.**

Keywords*— *Metaverse, blended learning, virtual learning, personalized learning, metaverse types, artificial intelligence, education models

I. INTRODUCTION

The concept of "metaverse" is not a very recent one. Rather, it was first mentioned by Neal Stephenson in his novel 'Snow Crash' in 1992. Subsequently, many other metaverses came into existence out of which Second Life as developed by Linden Lab 2003 became very popular. However, it created a great stir and wider audiences with the official announcement of the change in the company name from Facebook to Meta by Mark Zuckerberg in October 2021. A few platforms like Roblox, Sandbox, and Omniverse as developed recently by the industry giants have revealed the motivation and demands for constructing a metaverse.

Metaverse is an immersive virtual ecosystem that combines the physical and virtual world and is facilitated by the convergence between the Internet, Web, and Extended Reality (XR) that covers Mixed Reality (MR), Augmented Reality (AR), and Virtual Reality (VR) [1]. Moreover, Artificial Intelligence and Blockchain are the key technologies for developing metaverse. A virtual world is a persistent, computer-generated environment where the users meet and communicate with each other just as they would in a shared space [2]. Metaverse enables multisensory interactions between virtual ecosystems, physical entities, and digital twins. A metaverse development needs to go through three stages of sequential development namely *digital twins, native content creation,* and *co-existence of the physical-virtual world* [1]. Digital twins are digital models of entities, processes, products, or services as representations of the physical world. They are generated/simulated by computers, 3D scanners, and developers based on the original physical objects. Physical and digital twins are connected through data [3]. The parameters of the digital devices can be collected through ubiquitous sensing technologies to maintain the same state as their corresponding digital twins. The parameters in the virtual environments can be sent back to the physical devices after processing in the metaverse and their real-world states can be changed [4]. Digital natives or content creators are avatars and their human users with sufficient technological expertise in the digital ecosystem to work on new creations in virtual worlds. Mergers and connections of the physical and virtual represent the co-existence of the physical-virtual world. An ideal metaverse application needs to be *shared*, *persistent* and *centralized* which makes it different from traditional AR and VR applications [5]. It supports developing social experience and a "parallel world" to emerge.

A. Motivations

Online education has become quite popular in recent years with the advancements of ICT and the Internet. The openly accessible Massive Open Online Courses (MOOCs) are regularly attended by a large number of participants across the globe. Moreover, the radical shift towards online from traditional offline classrooms has been aggravated due to the global pandemic that needs maintenance of physical distancing. Online education mainly deals with synchronous and asynchronous teaching-learning systems. Synchronous systems enable teachers, students, or professionals to interact in real-time or at the same time in a digital virtual space. A few common synchronous platforms are MS Teams, Zoom, Webex, and Skype. On the other hand, in asynchronous systems, the participants can participate according to their own time and schedule. The automated tasks reduce repetitive work and save time for the teachers or trainers. Learning Management Systems (LMS) like Moodle, Blackboard and

social networks are a few examples of asynchronous tools. However, the existing applications under the mentioned synchronous and asynchronous platforms are based on 2D web-based environments. These environments have limitations like the lack of immersion and full engagement, unlike traditional classroom teaching. There is usually emotional isolation which is detrimental to motivation for participation. The following limitations of the 2D platform can have a negative impact on education and training [2].

- Limited self-perception with no personalization options.
- Students are confined to passive participation with limited opportunities to participate or act.
- Limited scopes for the teachers and trainers for explaining or delivering the content in digital mode.
- Difficult to assess properly the student's feelings and attention in the classes.

On the other hand, using 3D immersive technologies for the development of innovative metaverse applications can overcome the 2D limitations. Moreover, the importance of the metaverse applications will continue to increase and will also provide useful solutions during future unforeseen critical medical, climatic and political situations as well as take care of hazardous and costly issues of the physical world. Education and training is one such important domain where the metaverse can have several useful applications. With the rapid advancements in learning methodologies and immersive technologies, it is high time to implement innovative metaverse projects in education and training. Some studies and research have been conducted recently to explore the possibilities of a metaverse in education, mainly on academic campuses. However, no work or literature review, to the best of our knowledge is available that has considered the application of metaverse in training or developing skills for industry professionals along with academics in a holistic manner through an integrated environment. Moreover, no discussion is known to be available on how metaverse can benefit the physically challenged and financially backward students in general.

B. Contribution

The present article has tried to address the following questions through exhaustive studies and proposing a few novel ideas.

- How metaverse can create innovative teaching-learning possibilities for students, instructors, and trainers in terms of blended/hybrid, mobile, collaborative, personalized, project, and problem-based methods and techniques?
- How the potentials of the metaverse can be effectively utilized in education and corporate training with the blended virtual-physical approach?
- How the students, academics, and industry professionals will be benefited from Metaverse in education and training?

II. TEACHING-LEARNING PRELIMINARIES

A. Concepts and Applications

The teaching-learning process has undergone a paradigm shift towards dynamic and interactive education during the last few years, especially due to the pandemic and with the advancement of ICT and emerging technologies. A few such useful teaching-learning methods and techniques are blended / hybrid, mobile, collaborative, personalized, project-based, problem -based and artificial intelligence.

1) Virtual learning

Virtual learning is learning using computing devices and the Internet, inside as well as outside the facilities provided by an organization. A virtual learning environment is used to develop creative interactions and active learning environments in conjunction with collaborative learning. LMS, MOOCs, and various synchronous and social networking platforms are examples of virtual learning.

Teachers and trainers can provide instructions, upload virtual learning resources, and can interact with the students in real-time also. Students can access links, e-resources, and digital libraries, and explore and share resources in groups or individually with their peers. Students can attend virtual sessions by teachers/instructors or industry professionals, study through MOOCs, perform individual or group activities (projects, internships, virtual labs, simulations), participate in online discussion forums to clarify queries or doubts, complete assignments and submit to the teacher or uploading in the LMS and attempting tests/quizzes. It increases the inclusivity, better skill development, and proficiencies of the students without physically attending classes. Remote hands-on demonstrations can be given from the labs and offices by technical professionals using suitable tools and technologies.

2) Blended / Hybrid learning

Blended or Hybrid learning is a method that combines virtual/digital learning with traditional classroom and face-to-face teaching-learning. Blended learning provides a proper balance between online technology-based learning that keeps the student continuously engaged and motivated on one hand while the teacher /trainer-led instruction personalizes the learning experience and provides the human psychological issues of encouragement, compassion, and caring guidance. This learning environment can provide better student learning outcomes, teacher and student interaction, time management, and flexibility.

In addition to the several synchronous and asynchronous activities mentioned in virtual learning, Face-to-face learning is applied to resolve student queries based on self-learning or group learning, provide instructor's lectures, explain complex concepts to students, conduction of physical laboratories, hackathons, workshops, implementation of innovative ideas, exposure to real-world to students through field visit or visit to organizations to understand processes related to learnings and on-campus tests and assessments.

3) Mobile learning

Mobile learning or M-learning is an educational interaction system that is delivered to students located

anywhere and anytime through various types of mobile devices like Smartphones, Tablets, Handheld PCs, and Laptop PCs. M-learning is convenient for the students as the environment is highly portable, and collaborative and provides social networked learning and educational gaming.

Mobile cloud learning is a novel unification of cloud computing and mobile learning. In mobile cloud learning, learners can access content, such as text-based documents, audio, and video files, over the cloud via their mobile devices connected to the Internet. Mobile learning can be carried out in conjunction with flipped learning [6, 7].

4) Collaborative learning

Collaborative learning is a group-based approach where the learners solve problems, complete tasks, and learn new concepts in pairs or groups. It gives an opportunity for the students to collaboratively work on a common problem or task to learn and grow from each other. It helps to achieve critical thinking, usually more effective and efficient than individual learning as there are more information sharing and knowledge gathering, faster problem solving, more student engagement, and a better understanding of classroom material.

Collaborative learning has become quite effective in the workplace. Experienced employees can provide training including hands-on to the new employees or trainees utilizing their experiences and applications of new emerging collaborative tools. It helps to develop leadership skills, involvement, and team spirit among these employees.

5) Personalized learning

Personalized learning is the method in which the pace of learning and instructions are tailor-made or customized according to the learner's needs. It can result in skill and knowledge development and can result in curious, engaged, and life-long learners. A very simple example of personalized learning would be when an instructor provides learning material with proper content and context in the best way for the learner. It is based on the existing knowledge that the teacher/instructor has of the student. Needs to be a purposeful design of blended instruction to combine face-to-face teaching, technology-assisted instruction, and student-to-student collaboration to leverage each student's interests for deeper learning. Conferring is a process in which the goals of personalized learning can be achieved.

Learning for individuals, especially for the rural and students having lesser privileges can be developed with the help of emerging technologies. Cloud-based digital learning with smart devices has become quite popular for developing personalized learning.

6) Project-based learning

Project-based learning is acquiring knowledge from the core curriculum first and then applying the knowledge for hands-on solutions to related authentic problems and producing desired results. This instructional methodology is meant for the students to apply knowledge and skills through an engaging experience in real-world relevant projects. Critical thinking, creativity, collaboration, and communication are a few key skills that a student can develop through project-based learning. Students or industry professionals can take the advantage of digital tools including project-management tools to develop high-quality, innovative, and collaborative products.

7) Problem-based learning

Problem-based learning is the method in which the students are usually given open-ended problems for solutions and can learn by working in groups. It helps to develop problem-solving, research skills, working in teams, self-learning, and communication skills among the learners. Unlike project-based learning where the learning goals are already set at the onset, the learning goals and the outcomes of problem-based learning are flexible and jointly set with the teachers. For example, students can pitch innovative ideas to solve societal problems and create business plans.

8) Artificial Intelligence-based learning

Artificial Intelligence (AI)-based learning is one emerging method that can revolutionize the teaching-learning system. It has already been used to develop some tools that can help to develop efficient, personalized teaching-learning and can do the necessary analysis to find gaps in education with suggestive guidance to teachers and students. AI-based learning can be quite useful for corporate training where content can be adapted to create customized learning sessions. In Corporates, need-based and short training sessions are required. AI can analyze the skills, competencies, needs, and goals of the employee and transform the content accordingly into short sessions.

B. Metaverse Types

The Acceleration Studies Foundation (ASF) declared the metaverse roadmap in 2006 and presented the 4 types of metaverse: *augmented reality, lifelogging, mirror world, and virtual reality* as shown in Fig. 1. It also includes two axes namely 'Augmentation vs Simulation' and 'External vs Intimate' [8, 9].

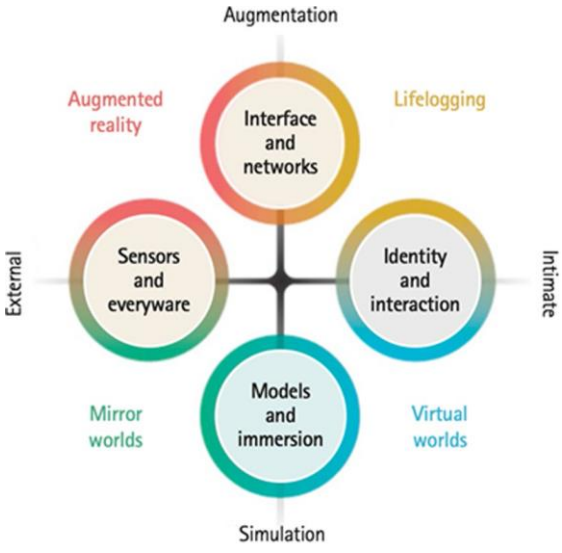

FIG. 1. A DIAGRAM OF 4 TYPES OF METAVERSE [8, 9].

Augmentation superimposes digital information on the existing physical world that we perceive while *Simulation* includes techniques to manipulate models of the physical

world and creates interactions and experiences in the virtual or simulated world. *External* world technology is mainly concerned with the users' external environment while the *Intimate* world focuses on the identity and behavior of individuals or other entities where the inner world can be achieved by the creation of *avatars* or digital profiles in which the users have the agency in the digital environment. A brief discussion on the 4 types of the metaverse is provided below.

1) Augmented Reality

Augmented reality is a type of augmentation of the external world. It refers to the technology that builds a smart environment by utilizing location-based technologies and networks. It uses Global Positioning System (GPS) and Wi-Fi in mobile devices to provide linkage information suitable for users' location information. It overlays objects in the real world and makes real 3D objects. Zepeto is a social media app that can recognize faces and create avatars.

Augmented reality finds useful applications in education, and health sciences like surgeries, smartphones, and vehicles HUDs.

2) Lifelogging

Lifelogging, an augmentation of the internal world features utilizes a technology that capture, store and share everyday experiences and information about people and other entities. Social media and SNS like Facebook, Twitter, Blogs, and YouTube are a few examples.

3) Mirror worlds

A mirror world is a metaverse where the appearance, information, and structure of the real world are transferred into a virtual reality as if in a mirror. It is a simulation of the external world. Map-based services like Google Earth, and Google Maps Naver maps are a few applications. Digital Labs and Virtual Educational spaces like Zoom, MS Teams, and Webex are two useful applications in education.

4) Virtual World

A virtual world is a metaverse where the user feels that they are in a virtual reality. The virtual world is built with digital data. Virtual reality technologies include 3D graphics, avatars, etc. It is an Internet-based 3D space in which multiple users can simultaneously participate by creating avatars that represent the user's self. Second Life, Roblox, and Zapeto are examples of virtual reality.

III. Metaverse in Education and Training

In this section, the scope and potential of Metaverse in innovative education and development, brief reviews of a few recent works on the use of Metaverse for the same, and challenges in general.

A. Potential of Metaverse in Education and Training

It is quite apparent from the previous discussions that metaverse can be widely applied in various fields including education and learning. Again, due to the COVID-19 pandemic or a few other socio-political situations when only face-to-face communications for instructions and learning have become very difficult the only possible offline mode of learning is being converted to online or blended mode. Here, the potential of the metaverse can properly be harnessed to create immersive learning possibilities through an innovative blending of virtual reality and physical classrooms, laboratories, or corporate training rooms.

Studies on Metaverse indicate that the same has been used in education to create new learning possibilities for the collaborative, creative, project, and problem-based learning [10]. It can also help to realize different types of learning methods like virtual, blended, collaborative, personalized, and problem-based learning [9, 11]. Few studies also focus on the use of mobile and hybrid learning for the metaverse in education [12]. Recently, AI-based methods are gaining prominence for personalized learning that can help in developing innovative methods considering the personal data and preferences of the users [4, 13]. The tools and technologies associated with metaverse can able to provide huge pedagogical support to the learners and enable them to have immersive learning experiences. Several learning methods and virtual technologies can be combined to provide immersive experiences as shown in Fig. 2 [9].

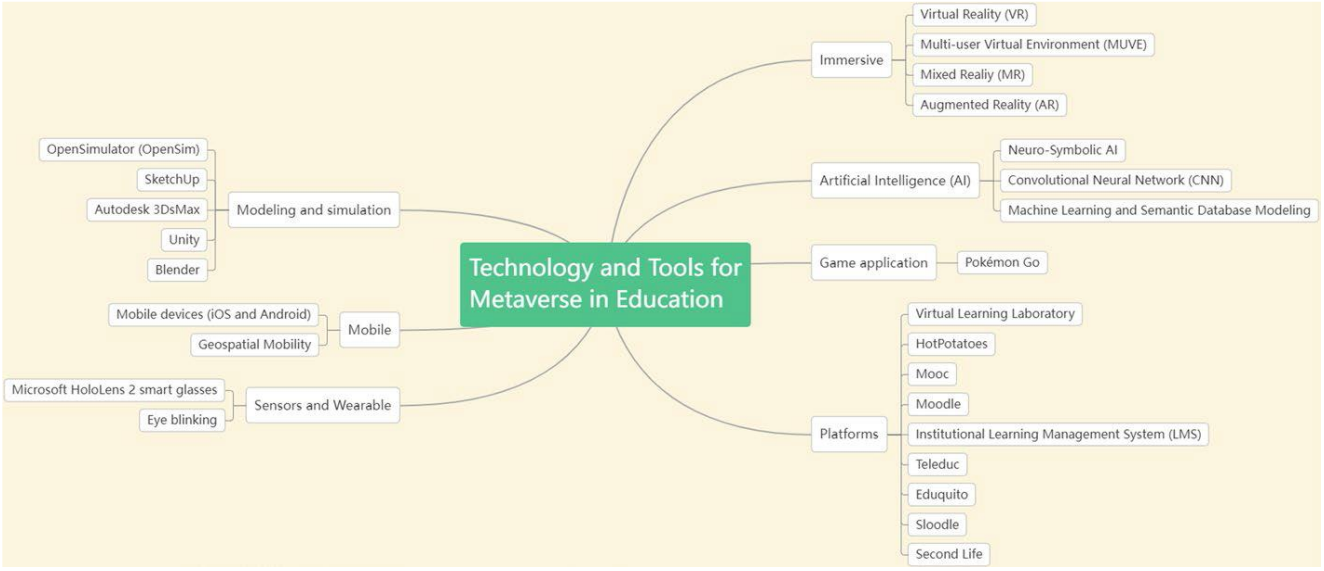

Fig. 2. Technology and Tools Used in Metaverse in Education [9]

B. How metaverse can create innovative teaching-learning possibilities?

The various learning methods discussed so far can be made attractive and useful to learners and instructors /trainers through the use of the metaverse with its associated tools and technologies. The same can be an ideal platform for the teaching-learning process. The following few innovative propositions are listed below for utilizing the potential of a metaverse in education.

1) Effective professional training and development

An educational metaverse can include academic institutions like schools, colleges, universities and professional training institutes on one hand and corporate bodies or professional spaces to provide the learners the opportunity to acquire real-life knowledge and professional experiences that they may not have the possibilities to gain in the real world due to unavailability of necessary resources, high costs or risks. The learners can participate in various training and development programs including hands-on through laboratories and project internships, regardless of time and space constraints. It can be a very cost-effective platform for professional training.

2) Simulation potentials of the metaverse

The strong simulation capabilities of Metaverse can be effectively utilized to teach learners or train the employees of organizations and for innovative developments. It is not always possible to teach or train effectively through traditional lectures, presentations, or providing textual materials as everyone usually learns in different ways. However, in Metaverse, it is possible to engage the sense of sight, hearing, and touch of the learners to create a realistic world that can appeal to the specific learning styles of the learners. Metaverse can simulate real-life boardrooms and workplaces. It can create virtual boardrooms that can give the employee a sense of face-to-face interactions. Unlike real remote video meetings, virtual meetings can be more engaging with lesser distractions. Simulation tools with 3D virtual and augmented reality technologies along with haptic technology can be utilized for the implementation.

3) Innovative mentoring platform for the teachers and trainers

Metaverse being an innovative technological environment covering emerging fields of computer science and educational technology it can be beneficial for the teachers and trainers to get trained by mentors and industry professionals having both theoretical and practical expertise on the latest applications of metaverse tools and technologies in education. As a result, the mentee should be well equipped to design innovative education metaverse and further mentor their colleagues and students. In this context, 6C's i.e. Collaboration, Communication, Content, Critical Thinking, Creative Innovation, and Confidence as mentioned in [11] can be considered.

Instructional design or learning strategies need to be developed in innovative ways for Metaverse platforms. The traditional concept map for the real world can be modified from 2D to 3D to depict the objects dynamically and more realistically including eye/body movement and voice recognition technologies. This will help the learners to make a deeper connection with the virtual world and gain better concepts on the subjects. Complex concepts, processes, and procedures can be better visualized and understood. On-job scenarios and case studies on real-life applications can be provided as exercises. Again, social relationships, interactions, or communications covering participants' expressions, body language, touch, and smell should be important considerations in the Metaverse design. It is possible to preserve social interactions if the virtual environments served as a prompt for interactions between real people in either the real or virtual setting rather than as a substitute for interaction.

4) Personalized learning and assessments

The learning capabilities of the learners vary due to several personal factors like knowledge levels, the pace of learning, absorption powers, the pressure of keeping up with other students, preferences, learning motivations, and attitudes. The students get an opportunity to learn and improve in a Metaverse environment with the scope of continuous support from mentors/tutors, peers, or other learners depending upon individual personal factors. Artificial Intelligence (AI) and Machine Learning (ML) can play important roles here. AI can be used to create automated virtual learning experiences through NPCs or Non-player characters [13]. NPCs act like humans in the metaverse. An instructor or physical tutor may not always be there to take care of individual students. So, the availability of an intelligent tutor or NPC can be useful for each learner. They may act as the learners' or employees' guides by answering frequently asked questions, evaluating their performances, and providing real-time feedback. Several AI assistances like facial recognition, sentiment analysis, gesture and body language analysis like eye movement/blinking, head movement, and hand movement of the learners can be helpful to understand their attentions, comprehension perceptions, and brain retentions. Again, ML can be used to collect data from previous teaching/training sessions of learners /employees to fine-tune the performances of courses over time.

5) Entrepreneurship skill development

In real-life courses, it is not always possible for the learners to experience e-business on their business ideas and make decisions as the associated costs are too high. But in Metaverse, the learners can be given the opportunity to create situations or environments to take it further and take decisions. Learners can collect information and create virtual workrooms to share and plan with other learners or get guidance from skilled entrepreneurs or NPCs. The development of business ideas and the necessary funding support can also be realized through the environment. They can further interact with other users in the Metaverse associated with similar businesses or products on various related issues to have real-world experience.

IV. Proposed Implementation Platform

We have already witnessed the limitations of traditional physical classes and laboratories due to the global pandemic or other emergency situations and the lack of engagements or

social relationships, interactions, and communications in online classes or passive classes through video conferencing. Again, the existing AR / VR education provides 3D visualization and immersive teaching-learning experiences but fails to provide remote access and communications. So, a blended Metaverse system can provide a solution to these existing limitations and provide more student engagement, motivation, and efficient learning with innovative combinations of 3D visualization, and online and physical methods. It can provide support to the learners not only during class hours but anytime and from anywhere. The integration of virtual tools with the teaching/training tools like Blended learning, Mobile learning, Inverted or Flipped classrooms, and social networks can also help to develop a dynamic and interactive system. [12].

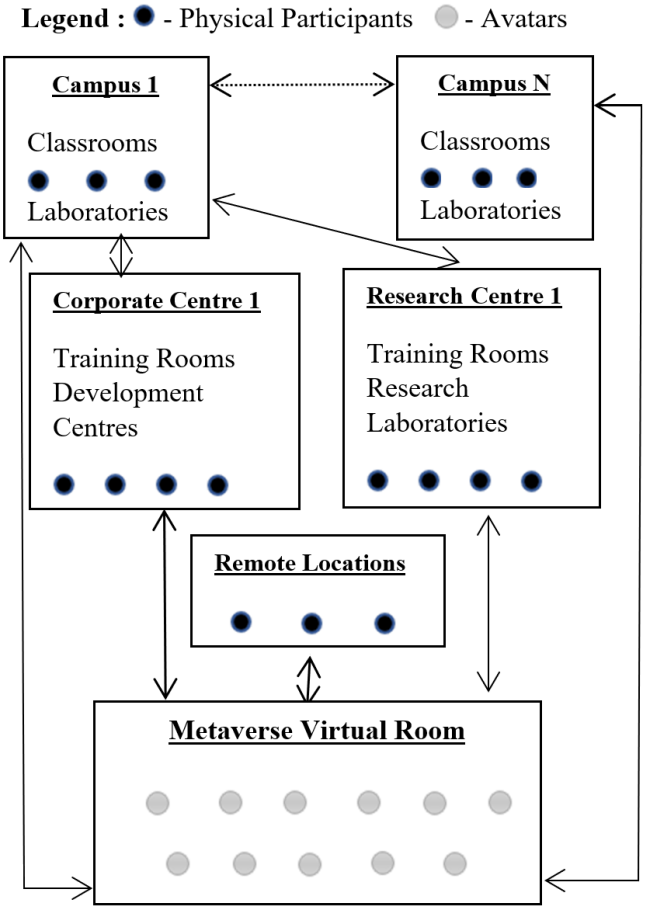

FIG. 3. VISUALIZATION OF METAVERSE EDUCATION AND TRAINING PLATFORM

An innovative blended teaching-learning platform in Metaverse is proposed here that can connect multiple physical campuses of universities/institutions, corporate development centers/workspaces, research centers, and online users. It aims to provide more engaging, interactive communications, and newer and enriching learning experiences among participants like instructors /trainers/ professionals and learners like students/employees from different campuses as well as online participants. All the participants can have the opportunity to attend the same activity like classroom instructions/ training/ laboratory hands-on/ workshops happening at one physical location or in online mode. It can provide instructors to gain time and create unlimited possibilities for innovative curriculum design with scope for continuous additions of experiences and new features. The learners can also be engaged in activity-based, collaborative, problem and project-based learning where they have the scope to get mentorship and hands-on guidance from industry mentors too.

The proposed Metaverse Education and Training Platform can be visualized in Fig. 3. Here the Metaverse Virtual Room bridge the physical participants from different campuses, and office locations and the online participants from remote locations together. All the participants are represented as their avatars (digital twins) in the Metaverse room and can be seen by all others remotely. The physically present participants of a location can meet virtually the participants of other locations. The detailed system architecture is not discussed here and will be communicated in the future.

The developed application corresponding to the proposed platform needs to have necessary infrastructural support like maintenance of bandwidth of user interactivity and able to be deployed on smartphones, browser-based cloud streaming, or maybe in other low-cost innovative mobile devices in the future. Open-Simulator [14] multiform can be considered for the development of the project.

V. CONCLUSION AND FUTURE WORKS

The recent pandemic situations have impacted our daily lives including work, teaching, learning, and training. We can foresee Metaverse to be a platform that can create a lot of opportunities for learning and training even in the areas which are not practically possible in today's real world due to limitations of social distancing, infrastructure, hazards, time, and costs. With the growing interest of the corporate world including a few renowned multinational companies, the research and development on applications of Metaverse in education and training will increase significantly in the current decade to meet the growing technological challenges and needs of the academic and professional world. The present work is a novel initial approach for the creation of an innovative blended environment for teaching-learning and its applications in the industries through proper training.

However, there are a number of current challenges to the creation of the metaverse platform that need to be addressed to make it useful and acceptable among the masses. A few such challenges include the design and creation of innovative content, powerful hardware, high-speed networks, and low-cost and lightweight devices with high resolutions to enable the users to experience an immersive and personalized system. In the future, research will be carried out to design suitable architectures to address these issues and also explore the possible ways by which the platform will be beneficial for physically challenged and financially backward learners who cannot afford costly devices or have sufficient infrastructural opportunities.

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