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The Metaverse in Education: A Comprehensive Review

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ABSTRACT

The metaverse, which is an invented universe containing rapidly developing online environments, enables a more dynamic learning environment. An improvement in asynchronous interaction that allows numerous individuals to share different observations is the metaverse. A method of study for implementing metaverse education is proposed in this paper. Applying the PRISMA approach, a systematic examination of the literature found 73 studies on the metaverse and learning. This study also offered a variety of uses, difficulties, prevalent topics in research, and potential use of a metaverse in education in decades to come. This suggested structure goes over a number of reasons why a metaverse should be used in education. The study attempts to fill the gap left by paucity of studies in schooling in the metaverse. Additionally, 27 new research topics were put up in this study for potential future study by scholars. Both learners and instructors at higher education institutions, universities, and institutions are going to benefit from this research.

Keywords: Metaverse; Education; Medical Services; Bibliographies; Systematics; Educational Institutions; Market Research.

1.0 Introduction

1.1 Background

Stephenson first used the phrase “Metaverse” in his work of science fiction, Snow Crash, which serves as a foundation for what it means in terms of language arts. However, as of currently, the term’s basic technical concept was entirely altered. In a contemporary society that is failing, where people are moving into a digital replacement for the World Wide Web called the Metaverse, this apocalyptic novel tells the life of the main protagonist Hiro. The science-fiction genre developed into an idea that was then attempted to be realised. For instance, among the earliest initiatives a technical transformation of a Metaverse was the Second Life platform in 2003[1], [2]. Considering its limitations in technology and the magnitude of its audience, the virtual world of Second Life was unable to make an impact.

1.2 Motivation

The following provided the impetus for this research:

- To guarantee that learners with disabilities have a comparable opportunity to advanced education: Individuals who find it challenging to fit into the traditional school atmosphere include those with learning disabilities like dyslexia or autism.

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They struggle to comprehend lectures, instructional content, and even their textbooks. They can't handle the stress caused by competition and require specific guidance.

- Examining the Problems Individuals with Learning Disabilities Face in Higher Education: People with learning challenges who struggle intellectually may feel stressed.

As a consequence, it's probable that anxious feelings of poor self-worth will manifest. Since they are afraid of making errors in what they do, numerous learners might not provide their best effort in class. Therewith determination and use of assistive technologies, people with learning disabilities can get beyond the stigma associated with them and successfully navigate the challenges of attending college.

- Enabling learners with disabilities to engage in educational endeavours and social interactions

The pupils will be able to engage in hands-on instruction thanks to the usage of technological aids. As opposed to passively seeking help, children can work cooperatively with other students or engage in individual learning activities. The adoption of technological aids enables students who struggle with education to progress at their own rate. Reduced stress and enhanced behaviours, focus, and ability to communicate are the consequences of this method of learning.

1.3 Methodology

To build the foundation for an innovative theoretical structure or idea as track the development of a particular subject across time, an examination of literature is essential. It was discovered that the methodical methods utilised in the research evaluation reduced bias and offered trustworthy results for making choices. The existence of specialty publications and particular issues for comprehensive reviews of literature is a result of the scholarly society's correct recognition of the importance of systematic reviews. Meta-analytic evaluations, method based review, domain based review, and theory based review are four distinct categories into which systematic examinations are divided. Identification, screening, eligibility, and inclusion were four phases of Preferred Reporting Items for Systematic Reviews & Meta-Analyses (PRISMA) procedure that the study adhered to [3].

2.0 The Role of the Metaverse in Education

The learner, time and place where the learner is located, and learning event have four keys that make up the learning scene in the education metaverse. The learning event refers to all events in the learning process, including the operation of learner's knowledge content acquisition and education metaverse apart from this knowledge content, like different types of sensor debugging [4].

2.1 Learner identity fusion

In the education metaverse, students have two identities: their real selves and their digital personas. Depending on the circumstances, the student "may be me" (the learner's real identity) or "may not be me" (the learner's digital avatar). This means that in the education metaverse, learners must be divided. According to scenes between real and virtual realms, these virtual/real identities vary in different ways. Thus, the three primary expressions of student identity in the educational metaverse are virtual avatars, true identity, & fused virtual-real identity[5].

2.2 Fusion of the learning spaces

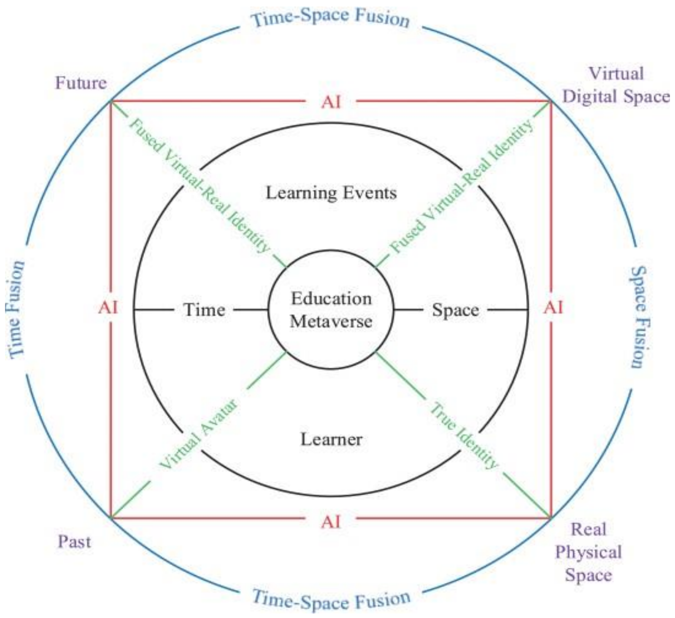
The learner's identities, learning environments, and other factors constantly alter the learner's metaverse space. Both real-world physical space and virtual digital space exist in the education metaverse. As the educational landscape evolves, there are several variances between reality and digitalization in both types of learning environments.

Both sorts of learning spaces have a range of differences between realism and digitization as the educational environment shifts.

2.3 Learning time fusion

Learning in the education metaverse may fuse time along with connecting the past, present, and future in a seamless way. In the physical world, this kind of connection is impossible. This learning time fusion's logical time integration, which is created by learner's virtual avatars, serves as its foundation. The logical past, present, and future can coexist in perfect harmony during the learning process [6]. The way we see time and all decisions concerning time are conclusions drawn regarding concurrent events, as Albert Einstein famously said. Figure 1 depict the type of fusion in education metaverse.

Figure 1: Fusions in Education Metaverse, these are three Kinds of Fusions: Learner Identity Fusion, Learning Space Fusion, and Learning Time Fusion[4]

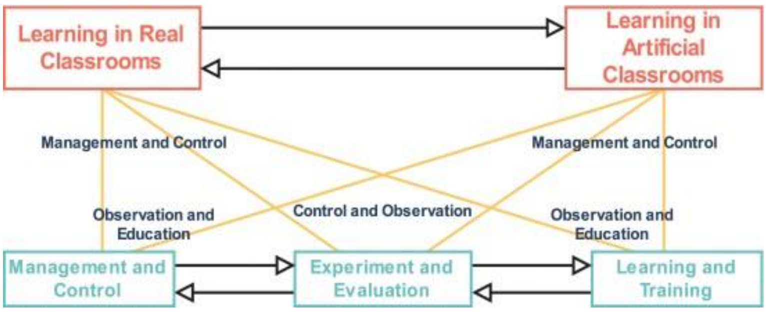


3.0 Applications for the Metaverse Ecosystem in Education

- Virtual 3D classrooms: As more online high schools and universities have shown up, students had begun to discover differences among immersive real and virtual classrooms. This gap will be filled by the creation of 3D virtual classrooms in metaverse, which allow students to communicate virtually with peers & teachers. In a metaverse powered learning environment, students from any area can participate and accomplish more than in a traditional classroom [7].
- Student participation in virtual campus activities such as sports and the arts is possible because to the metaverse. Numerous interesting activities are available for students to partake in, including campus athletics, music or math clubs, and other clubs. The virtual campus is also accessible to them from their homes.

- Creating environments that mimic real-world situations: Subject-specific 3D space might be developed for supporting student learning along with supporting teachers in more clearly communicating a subject matter. Knowledge in the metaverse engages students by mimicking real world circumstances where they can perform scientific experiments, give examples, and also take part in documentary movies, like one about World War I.
- Gamification: Although teaching topics to pupils in an interesting way is possible both statically, passively, and actively, the latter approach is the most effective since it does so. Metaverse achieves the same goal for students through gamification, which is the process of adding games-like characteristics to non-game items to raise user engagement. In figure 2 it is shown that how different learning in environment interact to each other's. As a result, pupils are inspired to keep learning and turn in their homework on time[7].

Figure 2: Learning Environment Interactions[7]



4.0 Challenges and Concerns to the Metaverse Implementation

Future breakthroughs in a wide range of fields could result from the emergence of the metaverse, but it still has a number of challenges that need to be overcome. A variety of technology, including augmented reality headgear, control devices, and potent computers, are still required for users to experience virtual reality, despite advances in the industry [8].

4.1 Technical and hardware limitations

The Metaverse is a broad term for a variety of technologies, including blockchain, artificial intelligence (AI), head-mounted displays (HMDs). This majority of Augmented Reality (AR), Mixed Reality (MR), and Virtual Reality (VR) devices are not sufficiently developed which suits the need of apps or user/avatar, despite the Metaverse's heavy reliance on these technologies. The creation of sophisticated head mounted displays (HMDs) which offer smooth & immersive experiences is one of the main problems. The HMDs need to be comfortable, light, and able to provide high-quality haptic, aural, and visual experiences. They must also work with several sorts of input techniques, including speech, sound, motion, and hand-based input [9].

4.2 Lack of standards and regulations

Another drawback of broadening the Metaverse's adaptation across domains is the difficulty of doing so.

4.3 Security and privacy

The Metaverse ecosystem had gathered a tremendous amount of information on users and avatars, including biometrics, facial expressions, and a wide range of other behaviours, to name a few. For complying with the data protection laws like General Data Protection Regulation (GDPR), these informations had to be private and user's information must be shielded from unauthorised access. A viable answer to many security and privacy problems in the Metaverse is secure by design,and built-in security, which is provided by endogenous securities theory. This endogenous security paradigm offers autoimmune skills as well as self-evolution, protection, and abilities [10].

4.4 The Darkverse

Which is more harmful than Dark Web because user identities are concealed behind avatar and there are no indexes, making it harder to police.

4.5 Sustainability of the Metaverse

A connection-based relationship can be difficult to establish in low-spec devices in order to maintain a steady state continuously. Users can seamlessly access the Metaverse for as long as they like by using an intermittent memory. The capacity for storing user experiences in memory has some restrictions [11].

4.6 Green Metaverse

If the Metaverse is to be sustainable, it should be environmentally friendly and resource-saving. In terms of dissemination of user-generated content (UGC), AIGC, collaborative computation, and networking, collaboration among avatars/users offer solutions[12] .

5.0 Case Studies and Implementations

To help readers comprehend the suggested methodology, case study is presented in this part. First, design of the Gridlock learning games in Metaverse is subjected to the ACP-based framework and accompanying methodology. The sets of real-world learner data is gathered through the Gridlock pilot testing conducted among the part of computer engineering courses [13].

5.1 Gridlock

Early computer engineering students are involved in metaverse learning as they create logic controllers for traffic lights in Gridlock while assuming the role of an engineer. In order to do this, students must apply the concepts and techniques they have learnt in class to create a workable solution. Students participate in games in the real world while the same game scene is playing simultaneously in a virtual environment thanks to ACP-based parallel control architecture. Eight issues are broken down into design of traffic lights in the game, and each one requires the players to possess expertise in a certain area that is necessary for the solution. Next, a tutor NPC is constructed using high-level agents and eight low-level agents. This NPC asks for feedback from students and tailors their learning processes. The project website and and have additional information about the Metaverse game[14] .

5.2 Experimental setup

We employ binary decision trees with learner variables to model learner responses that resemble those of humans. In order to fit the output of binary trees of decisions to the information gathered throughout the pilot testing, they have to be generated out to a particular depth. A single parameter and one result are selected to serve as the dividing criteria for each node of the tree. Utilising real-world data, the possibility of actions at each leaf node are divided into five distinct groups: "very good," "good," "neutral," "bad," & "very bad." Therefore, iteratively navigating these decision trees using produced instances of learner data, the system reliably determines what measures are appropriate according to circumstances in a method that accurately represents the real-world data. Table 1 shows the network and Agent hyper parameters for experimental setup.

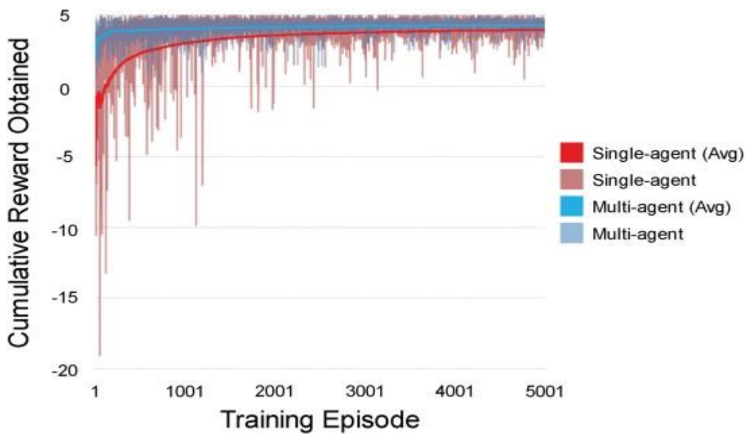
Table 1: Network and Agent Hyper Parameters [15]

Parameter	Description	Value
α	Learning Rate	0.001
γ_h	High-level Discount Factor	0.9
γ_l	Low-level Discount Factor	0.9
k	Update target network every	5
b	Training batch size	200
ϵ	Exploration Factor	$0.8 \rightarrow 1.0$
r_c	Completion Reward	3
	Decision Tree Depth	7
N	Number of Low-level Agents	8
$\|A_l\|$	Number of Actions per Low-level Agent	8

5.3 Comparative results

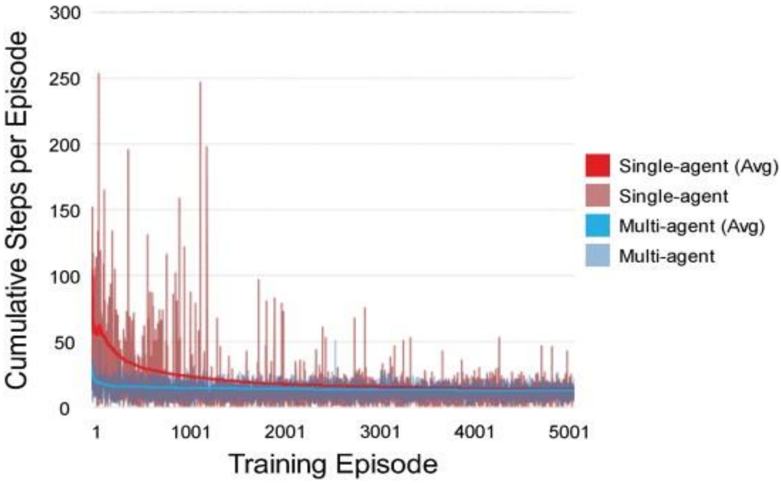
Two independent computational tests are carried out to verify the system's functionality in its entirety. In the first experiment, a single-agent strategy is contrasted with the multi-agent hierarchy that is suggested, which uses a high-level agent and N=8 low-level agent—8 being chosen as a balanced amount of low-level agent and subtask[16].

Figure 3: Single-agent RL versus HRL Average Cumulative Reward Obtained per Episode[4], [17]



This cumulative reward earned by both agents for each episode over 5000 training episodes is compared in Figure 3. An episode entails students engaging with the system for the first time and receiving help with each subtask until data is satisfactory. It's evident that hierarchical technique had significantly raised the average reward during initial training phases. According to the Mann-Whitney U test, the cumulative incentive significantly enhances the performance of hierarchical agents, with an effect size of 0.8101.

Figure 4: Single-agent RL versus HRL Total Step Taken perEpisode until Completion by all Agents[4], [17]



In Figure 4, the average reward for each episode across the eight agents and the four cases is compared. As demonstrated, the average payout of our suggested strategy is superior to all others. By using Mann-Whitney U test, it's compared to the second-best scenario (i.e., case 2), and effect size is 0.3890. Additionally, all multiagent systems outperform the single-agent strategy in terms of performance. This supports our claim that multiagent techniques are better able to acquire more specialised behaviour than single agents, who would need longer time to develop generalised behaviour across all tasks. Even in the early training phases of our suggested strategy, weighted experience sharing improves the overall reward of all agents [17]. This system's performance (effect size of 0.1765) shows the shared experiences had to be weighted because it doesn't accurately reflect the dynamic of the target agent. In fact, the system performs worse without weighing knowledge fromvarious agents than a conventional multiagent strategy.

6.0 Conceptual Model and Hypotheses

6.1 The personal innovativeness and tam constructs

Consumers of technology are categorised as innovators and information seekers by the innovative model. When there is a lot of uncertainty, technology users can adapt well and are more likely to adopt and use it. As a result, PI urges people to adopt a positive attitude towards technical advancements [18]. The degree to which a user of technology believes it would be helpful is known as PU, but the users' perception of how much effort it will take to employ a particular technological advance is known as PEOU. The following theories serve as the foundation for this study:

1. Perceived Usefulness (PU) would be predicted by Personal Innovativeness (PI).
2. Perceived Ease of Use (PEOU) would be predicted by Personal Innovativeness (PI).

6.2 The users' satisfaction and the perceived trialability, observability and compatibility

It is crucial to consider US, PTR, POB, and PCO when assessing technological adoption. One of the most important indicators of technology adoption is user perception of an innovation's usefulness. User satisfaction, trialability, compatibility, & observability in particular used to forecast how well and to what extent technology will be accepted and used. In order to successfully accept new technologies, users must have favourable US, PTR, POB, and PCO. After using a particular technical advancement, users of technology might affirm or refute their opinions about it. Users may say that technology has improved their lives. The acceptance and application of technology remain in such circumstances [19]

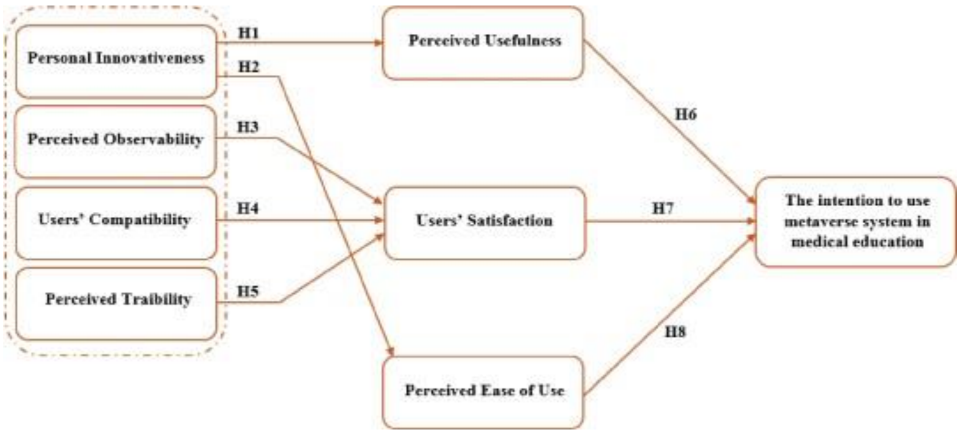
By studying the impact of PTR, POB, and PCO on US acceptance of technical innovation, notably MS,current study attempts to close the knowledge gaps. As a result, the following theories are proven:

1. Perceived Observability (POB) will be predicted by Users' Satisfaction (US).
2. Users' Compatibility (PCO) will be predicted by Users' Satisfaction (US).
3. Perceived Traibility (PTR) will be predicted by Users' Satisfaction (US).
4. Perceived Usefulness (PU) will be predicted by Users' Intention for Using Metaverse Systems (UMS).

6.3 The conceptual framework

By focusing on US and PI, the two key components of UMS, the conceptual framework of current studies seeks to evaluate UMS. Other predictors, which includes PTR, POB, PCO, PEOU, and PU, link two factors together. PTR, POB, and PCO are used for evaluating the US, whereas PEOU and PU are used to evaluate the PI, shown in Figure 5. These theoretical models are initially tested using a SEM, and then the ML method is used[20].

Figure 5: Research Model [20]



7.0 Discussion and Future Work

The fact that there might not be agreement between the business and scientific views of the Metaverse raises new research challenges. Researchers could look at which significant corporations are engaged in Metaverse projects at the moment and how they define the concept. To achieve this, the public should actively monitor the progress of the key Metaverse initiatives to make sure that all businesses act in the best interests of the Metaverse as a whole rather than only acting in their ownbest interests. Since the Metaverse would have its own open standards and would not follow the Internet as its example, such a development might be in conflict with that. The societal consequences and the technological implications represent the two main issues that can be inferred from the reviewed literature [21]. Table 2 includes recommendations and suggestions for future research as well as a summary of the key problems and problems found in the collection of literature.

Table 2: Research Agenda [17], [21], [22]

Main Challenges	Issues	Research Recommendations
Societal Implications	Social	Identification of the necessities for an enhanced accessibility for end-users
		Investigation of the impact on interpersonal interaction and human-machine interaction
		Determination of the overall ethical boundaries
		Investigation of the impact on privacy
		Investigation of the alignment of cultures regarding the amplification of globalization effects
		Investigation of the emergence of a Metaverse culture resembling the Internet culture
	Economic	Investigation of the change on financial markets and goods markets
		Investigation of the change of financial transactions and the transfer of digital goods
		Investigation of the change of economic processes through use of further Web 3.0 technologies such as blockchain or decentralization
Technical Implications	Open Standards	Identification of the necessities for an enhanced interoperability between Metaverse platforms
		Identification of the necessities for an enhanced uniform utilization of further Web 3.0 technologies such as blockchain or decentralization
	Hardware	Identification of the necessities for an enhanced interoperability between different end-user devices such as smartphones, tablets, and personal computers as well as other AR, MR, and VR devices

In conclusion, according to literature, the project shows how Metaverse will consist of a single three dimensional online environment along with numerous Metaverse platforms, each of them exists in a structure of simulated spaces [23].

8.0 Conclusion

In this article, the education metaverse's learning scenario is examined, and an academic framework for the education metaverse is suggested. It involves the student's time and space, and learning events in the education metaverse. We also suggest a brand-new framework for group intelligence that is powered by data and knowledge for education metaverse's learning scenes. In fact, this article just presents preliminary researches on smart service in education metaverse. They anticipate that this is merely a door (or a start) and that academics will continue to ask and answer many additional inquiries in the years to come [22].

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