# A Chain of Worlds: Education in the Age of Metaverses

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## ABSTRACT

This paper explores the contexts and applications of metaverses, their potential, and possible best practices in education. The paradigms of learning are shifting, driven by new frontiers in learning through the advent of metaverses and augmented reality digital technologies. The future of education and work is evolving into a fluid landscape with uncertain job and career trajectories due to volatility, uncertainty, complexity, and ambiguity. The structuring of education as a menu of predefined disciplines and degrees situated in brick-and-mortar educational institutions may no longer be an optimal model. The evolution of three factorsaugmented reality digital technologies such as metaverses, big data, and global demand for a tech teacher workforce versed in Technological Content Knowledge, and Technological Pedagogical Knowledge will have far-reaching consequences for the field of education. Cognitive architecture and global, interactive, immersive, and real-time online spaces are poised to become fundamental game-changers.

Algorithmic approaches to decision-making are starting to permeate both institutional and personal spheres through decision support systems. In education, artificial intelligence and intelligent systems will become change agents with deep impacts not only on assessment, administrative functions, organizational strategic planning, student acquisition, and retention but also on curriculum design and pedagogies.

**Keywords**: Metaverses, artificial intelligence, Technological Content Knowledge, Technological Pedagogical Knowledge, Augmented Reality Digital Technologies, metaverses.

## THE BIG SCOPE: PAST AND PRESENT

Education, educational institutions, and the use of tutors in education date back to 3500 BC. Egypt and the Middle East established major centers of learning with the invention of the written language. European education started with ecclesiastical establishments in monasteries during the Middle Ages. In 1330, a mere 5% of the population could read or write [1]. Education was reserved for members of the male aristocracy and religious orders, which jealously guarded access to literacy.

The focus of early U.S. schooling was to "teach children how to read the bible and how to align themselves with puritan morals" [2]. John Dewey's theory on progressive education promoted the central role of democracy in education. He believed that schools were not only a place for students to gain content knowledge but also a place for them to learn how to live. The purpose of education was thus to realize students' full potential and ability to use their skills for the greater good [3]. Dewey further noted that "to prepare him for the future life means to give him command of himself; it means so to train him that he will have the full and ready use of all his capacities" [3]. These are prescient words still today, during the transition from the Digital Revolution to the Fourth Industrial Revolution (4IR), a phase driven by dramatic technological expansion and social change. This change will eventually transform political, institutional, and cultural traditions.

4IR or Industry 4.0, is an ongoing and pervasive digitization of technology, industries, societal patterns, and processes. Yet the 4IR involves more than technology molding how we live, learn, work, and play. In the future, intense population growth in developing markets and extended life expectancies might fuel a massive economic expansion. Technological innovations will require and drive unprecedented educational demand in re-skilling and up-skilling for anyone participating in the global network of economies. Advances in multimedia, virtual education and virtual mobility, e-learning environments and platforms, and informal arenas of learning will lead to diverse learning opportunities in daily life and the workplace.

In today's post-pandemic world, a fluid landscape is developing with uncertain job and career trajectories due to volatility, uncertainty, complexity, and ambiguity (VUCA) in a post-pandemic world. The structuring of education as a menu of predefined disciplines and degrees in brick-and-mortar educational institutions may no longer be the best or most desirable model. The convergence of trends in three areas - augmented reality digital technologies (ARDTs), big data, and global demand for a highly qualified teacher workforce are poised to usher in far-reaching changes in the field of education. The 4IR will be responsible for new models of learning, leading the modernization of education systems. economies, and societies.

## OUTSOURCED AND AUTOMATED

In 2016, the World Economic Forum predicted that by 2020 "more than a third of the desired core skill sets of most occupations will be comprised of skills that are not yet considered crucial to the job today" [4]. The report further stated that "the 4IR is characterized by a fusion of technologies that blurs the lines between the physical, digital, and biological spheres. Thus, the 4IR is reshaping educational philosophies and their underpinning pedagogies by transforming the modes of delivery in educational institutions worldwide." In the interview *Radically Open: Tom Friedman on Jobs, Learning, and the Future of Work*, the Pulitzer Prize–winning journalist reminded us that whatever can be outsourced and automated will be. Friedman further stated, "In the age of Google, no one really cares what you know, because the Google machine knows everything. All they care is what you can do with what you know" [5].

## LITERATURE REVIEW

The World Economic Forum warned in its report *Our Education System Is Losing Relevance. Here's How to Unleash Its Potential* of an antiquated Industrial Revolution model that focuses on IQ, in particular memorization and standardization. The report recommended that educational approaches be updated to include

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"job readiness, the ability to compete against smart machines and the creation of long-term economic value in mind" [4]. The *2020 EDUCAUSE Horizon Report: Teaching and Learning Edition* identified as most important technologies and practices in the near future adaptive learning technologies; artificial intelligence (AI)/machine learning education. AI applications will drive analytics for student success; the elevation of instructional design, learning engineering, and user-experience design; open educational resources; and extended reality, augmented reality, virtual reality , mixed reality, and haptic technologies [6]. In its *Education in 2030* report, HolonIQ, the world's leading impact intelligence platform, unbundled the four drivers of the global expansion in education and outlined five scenarios: education as usual, regional rising, global giants, peer-to-peer, and robo revolution. The report further predicted significant population growth among school-age students, with 1 billion more students by 2030 and 2.4 billion more students by 2050 with global demand driven by Asia and Africa [7]. The National Research Council stated, "This post-industrial form of society calls for a new, post-industrial form of education" [8]. Finally, in *A Guide to AR and VR in Education*, Dr. Penny Thompson referred to VR, AR, and mixed reality as the "4th wave of technological innovation and change in the world of computing" [9]. Thompson further discussed the importance of considering learners' developmental stages before integrating technology into the teaching and learning environment [9].

## EDUCATORS AND TECHNOLOGY INTEGRATION

Educators' acceptance and use of technology hinges on perceived usefulness, ease of use, and user experiences as shown in Table 1.

**Table 1. Frameworks and Technology Integration**

| Framework | Description |
|---|---|
| **Pedagogical content knowledge (PCK)**<br>Pedagogical best practices aligned with specific learning objectives | Implementing best practices for teaching targeted content to specific target learner groups |
| **Technological pedagogical knowledge (TPK)**<br>Relationships and interactions between technological tools and specific pedagogical practices | Knowing how to use digital tools to achieve measurable learning outcomes through targeted experiences |
| **Technological content knowledge (TCK)**<br>The merging of technologies and learning objectives | Knowing how digital tools can enhance or transform content<br>Having insight into the complexity of implementing digital tools<br>Creating context-situated interactive experiences |

Technological, pedagogical, and content knowledge (TPACK) is a technology integration framework that identifies three types of knowledge educators need incorporating EdTech: technological, pedagogical, and content knowledge. TPACK recognizes the dynamic, transactional relationship among content, pedagogy, and technology [10]. TPACK unbundles and defines the skills and nature of knowledge required by educators tasked with integrating technology into their teaching while addressing the complex, multifaceted, and context-situated nature of teacher knowledge [11].

Technology in and of itself is pedagogically neutral; nevertheless, the increasing integration of technology into all aspects of education reflects a broader cultural shift. Utilizing such technologies to support learning in meaningful ways can help prepare students for success in the 4IR. Roberta Golinkoff and Kathy Hirsh-Pasek in their book *Becoming Brilliant* envisioned what successful learning encompasses in a dynamic, global world. They identified six learner competencies: collaboration, communication, content, critical thinking, creative innovation, and confidence [12]. Successful integration of metaverses into purposeful learning frameworks will require evidence-based, dynamic learning models that focus on these six competencies.

## METAVERSES AND INTELLIGENT SYSTEMS

The term *metaverse*, from *meta* (which implies "transcending") and *universe*, refers to virtual worlds "in which the avatar acts, and the avatar is the user's alter ego and becomes the active subject in the Metaverse" [13]. Extended reality is the medium that connects avatars in metaverses and users in the real world. Therefore, metaverses are substantially different from augmented or virtual reality. Metaverses are virtual worlds with access to three-dimensional (3D) virtual spaces, solutions, and environments, whereas virtual reality, a technology, is one of the components for interacting with a metaverse. Metaverses are open, shared virtual 3D worlds that continue to function after users log off, augmented or virtual reality experiences end once the user exits the program.

Metaverses lend themselves to the collection of big data, which eventually might go beyond text mining to include audio mining, to evaluate students' skills, self-reflection, and emotions. Metaverses will be able to collect and measure students' achievements, detect behavior and perform predictive modeling, and detect learners' behavior. In addition, big data–driven AI might predict career paths and carry out recruitment practices based on insights into learners' performance, motivation, and habits.

In education, AI and intelligent systems are poised to become change agents with deep impacts not only on assessment, administrative functions, organizational strategic planning, student acquisition, and retention but also on curriculum design, and personal learning networks. The global competitiveness of educational institutions and their graduates will rest on their ability to be agile and nimble in adopting adaptive technologies.

Key trends in the domains of big data and AI are associated with predictive analytics and AI. Big data work on the principle that a pattern of information appears with the collection of massive amounts of data. Through AI analysis, information patterns reveal previously hidden relationships. Analyzing and understanding such emerging relationships enable smarter decision-making and predictive forecasts in fields from medicine to the military, finance to education. Data sets consisting of volume, value, variety, velocity, and veracity cannot be manually processed using traditional data management techniques, such as spreadsheets. Hence, novel and innovative computational technologies are required for the acquisition, storage, distribution, analysis, and management of big data in education.

## THE POWER OF TRUSTLESS IMMUTABILITY

Education is already being impacted by AI through smart content, intelligent tutoring systems, virtual facilitators, and yet-to-be-invented learning environments. Over time, trustless systems that use some form of distributed ledger technology (DLT) will become common for administrative and organizational purposes. Blockchain or Holochain integration has the potential to disrupt through the global recognition and transfer of credits, the tracking of intellectual property, the use of verified sovereign identities for student identification, and the use of immutable certificates/micro-credentials.

Blockchains are distributed databases in which data are stored in blocks instead of structured tables. The use of DLT or blockchain technology enables not only portable and secure creation of digital identities but also educational record-keeping, conferrals of degrees, guarantees of the authenticity of student work and faculty research, plus digitalization of national higher education results. DLTs are characterized by decentralization, anonymity, immutability, auditability, and autonomy. Currently there are three types of blockchains: public, consortium, and private blockchains.

Non-degree pathways in information technology certifications for companies such as Google, Microsoft, Cisco, and Novell have created a parallel postsecondary universe. There are five types of DLTs: blockchain, directed acyclic graph, Hash Graph, HoloChain, and Tempo (Radix). Each of these DLTs has the power of trustless immutability [14].

## METAVERSES AND LEARNER GROWTH

Although metaverses can offer multidimensional immersive context, it is necessary to keep in mind sound pedagogical principles, the science of learning, and the impact of ARDTs on real children. Further exploration of the effect of avatars and child development in metaverses is necessary as "all individual users own their respective avatars, in analogy to the user's physical self, to experience an alternate life in a virtuality that is a metaphor of the user's real worlds" [15]. How might the four education domains of learner growth be influenced through learners' immersion in metaverses? Metaverses, ARDTs, and DLTs have the potential to foster learning and skills verification through simulations, digital kiosks, live virtual events, live interactivity, instructor-facilitated learning, AI-driven chatbots, and hyper-realistic experiences.

Metaverses are poised to transform how we socialize, learn, shop, play, and travel, and thus there are serious privacy concerns. Biometrics such as audio and iris recognition are becoming more prevalent, especially in immersive worlds. Today, if a student loses their password to a learning management system such as Canvas, the worst-case scenario is losing some data and having to create a new password to secure their institutional account. "However, since biometrics are permanently associated with a user, once they are compromised (stolen by an imposter), they would be forever compromised and cannot be revoked, and the user would be in real trouble" [15].

ARDTs enable multiple users to experience the same curated content. Such content personalization offers opportunities to accelerate learner understanding and deepen learner engagement. Institutions will need to plan for and integrate program coherence coupled with sustained learner contact at both the institution and educator as designer levels as well as continuously assess and evaluate technology tools, third-party vendors, faculty, and learners. Offering ARDTs with functional 3D immersive spaces such as metaverses requires a robust institutional, system-wide discussion of technology-enhanced learning. Integrating technology-enhanced learning not only requires a highly qualified educator workforce but also demands articulated, interconnected institutional, educator, and learner cultures as shown in table 2.

**Table 2. Institutional, Educator and Learner Cultures**

| Institutional Culture | Educator Culture | Learner Culture |
|---|---|---|
| System-wide understanding and general conceptions of teaching and learning in three-dimensional (3D) learning spaces such as metaverses. | Educators co-construct and implement 3D learning spaces together with design teams to support both learning and teaching. | Learners recognize and value the benefits of 3D immersive spaces for acquiring content knowledge. |
| Clearly articulated and legally vetted approaches to creating and/or configuring 3D immersive learning hubs such as metaverses. | 3D teaching is purposefully orchestrated and relies on sound pedagogical principles. | Immersive 3D activities are aligned with students' learning preferences. |
| Determining 3D learning space integrations as a vital part of university culture and learning systems. | 3D spaces meaningfully and purposefully engage learners with learner-centered instructional activities. | Avatars are appropriate and representative of the learner and the abilities needed to engage with and execute instructional directions. |

Purposeful pedagogical frameworks and designs are needed for metaverses, otherwise the multitude of activities, such as games or virtual social interaction, capturing learners' attention will interrupt learning experiences, thereby impeding knowledge construction and learner agency.

## METAVERSES: FRAMEWORKS AND BUILDING BLOCKS

Just like towns, metaverses feature different layers. Layer 1 is the supporting infrastructure, such as networks and hardware. Layer 2 hosts the virtualization engines. Layer 2 includes the computing parts and computing requirements, such as Cloud, Edge, and others. The computing parts enable the programming engines, such as 3D engines and geospatial mapping, that are needed to create user experiences. Virtual platforms, avatars, and asset creation are all part of layer 2. This means that assets such as digital twins are part of layer 2. Digital twins are virtual representations of real-time digital counterparts of a physical object or person. Companies have started leveraging the metaverse to be more akin to a video game. They do this not only for gamification purposes, engagement, and robustness of game engine tech, but to attract younger talent to otherwise traditional industries. Digital twins act as boundary spanners across multiple domains that not only transfer knowledge between people and systems but also retain it, possibly forever, in secure ways. Layer 3 is the interface and user access and encompasses hardware such as mobile devices, VR/AR, smart glasses, and any other displays. Layer 4 deals with user experiences and use cases. Experiences, education, content, events, payments, asset marketplaces, and financial services are part of layer 4. Currently governments and educational institutions are ill suited to vetting, analyzing, and evaluating layers 1–3.

## THE METAVERSE AS THE CLAVIS AUREA?

*Clavis aurea*, or “golden key,” refers to the means of discovering hidden or mysterious meanings. The complex, interconnected phenomena of metaverses promise to be the future clavis aurea, the golden key, on the path to the amplification of human intelligence. According to the Online Etymology Dictionary, the transitive verb *transform*, meaning to “change the form of,” is from the Old French *transformer* (14th century), the Latin *transformare* (to “change in shape, metamorphose”), and *trans* (“across, beyond”) [16]. Transformative uses of technology fundamentally change aspects of the learning process. Transformative pedagogy empowers students to critically examine beliefs, values, and knowledge with the aim of developing new epistemologies, centering multiple ways of knowing, and developing a sense of critical consciousness and agency [17].

Governments and educational institutions that implement ARDTs in traditional contexts will need to embrace VUCA while engaging in robust discussion and debate on the challenges to quality, evaluation, and accreditation that using these 21st-century tools will bring. Questions remain about how institutions might implement agile frameworks using ARDTs to monitor quality assurance and ensure quality management systems. How might governments and credentialing bodies deal with the standardization, assessment, and accreditation of in-world learning?

Introducing AI and intelligent systems into education will have profound effects on not only assessment and administrative functions but also faculty and learner motivation, engagement, and overall academic performance. Other areas that will be affected include organizational strategic planning, student acquisition and retention, curriculum design, and personal learning networks. Speed, agility, and collaborative intelligence will determine the competitiveness of educational institutions and their graduates in the global marketplace. Metaverses and ARDTs will need updated learning policy and development not only to modernize education policy but also to create fertile spaces to explore, expand, and eventually consolidate new learning practices and approaches for 21st-century knowledge societies.

Metaverses and future AI systems promise to accelerate human progress by pushing boundaries by amplifying the collective human intelligence. “Traditional classrooms and bureaucratic education systems cannot provide society with what it now requires. The agenda of the new learning is to meet the needs of the knowledge society in a globalized world” [18]. Empowered learners, digital citizens, and knowledge construction are tangible benefits of immersive environments. Free ARDT tools for educators include 3Bear Lessons, Merge EDU, Immersive Reader, Flipgrid, NearPod VR, CoSpaces, Big Bang AR, Adobe Aero, Thyng AR, Quivervision, Jig Space, Mondly AR, and the Metaverse.

In conclusion, unanswered questions remain in regard to the science of learning and the impact of ARDTs on real children. Moreover, there are concerns about the privacy of biometrics driven by big data aggregation. Nevertheless, metaverses in a chain of worlds might soon enable governments, educational institutions, educators, and learners to engage with one another and complex content and tasks in safe, realistic ways.

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