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Editorial: Examining Blockchain Protocols, Cryptocurrency, NFTs, and Other Web 3.0 Affordances in Teacher Education

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INTRODUCTION

Two things seem to be assured in education, particularly as they relate to educational technology and teacher education. First, technology evolves at a rate that is exponentially faster than many of us can keep up with (McElligott, 2018). Second, education also seems to lag in its attempt to integrate said innovations (Uerz et al., 2018). These are obviously generalizations; exemplar exceptions exist throughout PreK-12, post-secondary, and graduate education.

The reality, however, is that many technological changes that have gained mass acceptance globally and commercially are very slow to find their way into or to make an impact on teacher education. For instance, the title of this editorial mirrors a 2007 *Journal of Technology and Teacher Edu-*

cation piece written about social media (Ferdig, 2007). Social media generally, and *Facebook* in particular, were impacting how people connected with each other. Teacher educators at the time, however, were in the process of banning social media for preservice teacher use (mainly because they did not understand it), rather than teaching future teachers how to use it properly and for pedagogic gains.

A more recent example relates to K-12 online education. K-12 online and blended instruction arguably got its start in the mid-1990s (Kennedy & Ferdig, 2018). Millions of students have since made their way through online learning at levels ranging from kindergarten to advanced placement courses. However, when the COVID-19 pandemic shut down our lives and our educational institutions, many K-12 and post-secondary educators were left unscripted and unprepared; they had no knowledge of the 25 years of history, research, and best practices (Ferdig & Kennedy; 2014; Ferdig et al., 2020; Hartshorne et al., 2020; Kennedy & Ferdig, 2018). Some teacher educators and teacher education programs found innovative and creative ways to support teachers; others, unfortunately, were not fluent or practiced enough in online pedagogy to prepare current and future teachers (Ferdig & Pytash, 2021).

A new digital gap looms: it is the move to Web 3.0 and its related technological affordances (i.e., blockchain protocols, smart contracts, cryptocurrency, non-fungible tokens or NFTS). Introducing such an agenda typically elicits one of several responses. First, teacher educators will suggest that such topics fall purely under the purview of computer science (CS) and CS education. We agree to the extent that important efforts have been made in our collective fields to better prepare future students and teachers in broader concepts within CS (Qian et al., 2019), STEM (Milner-Bolotin, 2020), 21st century digital learning (Kim et al., 2019), etc. However, to suggest that Web 3.0 affordances (and related constraints) can be put within certain boundaries, content areas, or contexts of teaching and learning exemplifies a misguided and limited understanding of Web 3.0.

A second common response could affectionately be lumped under the *here-we-go-again* or the *flavor-of-the-week* banners. Teachers are often inundated with the latest theoretical framework, pedagogy, and/or technology that rears its head in seminars, professional development offerings, and inservice training days (e.g., Owens & Hudson, 2021). For instance, specifically addressing technology, what began as teachers needing to understand the personal computer (Scheffler & Logan, 1999) moved quickly to interactive whiteboards (Smith et al., 2005), learning management systems (Hill, 2009), augmented and virtual reality (Maas & Hughes, 2020), robot-

ics (Schina et al., 2021), and even machine learning (Aruleba et al., 2021). Such rapid changes see critics asking whether such technologies have made any significant difference in education (Cuban, 2018; Reich, 2020).

It also has many teachers and teacher educators saying, "this too shall pass" (Keyes, 2006, p. 159). Lambert (1998) describes this as the belief "that if we wait it out, keep on doing what we have always done, the new initiative will lapse into the heap of strategies and best intentions that have fallen by the wayside" (p. 13). The problem with such a response is that while Web 3.0 affords the implementation of new technologies, it does not refer to one specific technology. Rather, it is often described as a semantic or intelligent web (e.g., Dominic et al., 2014) that gives rise to many new technologies, potentially new pedagogical strategies, and evolving student and teacher skill sets (Poore, 2014). While very few educational futurists could have seen the dramatic change from the rise of personal computers to the technology-enhanced teaching and learning of today (arguably the move from Web 1.0 to Web 2.0), it would be foolish to not be prepared for the affordances of Web 3.0 simply because one assumes it is tied to a specific technology that will eventually pass.

A third frequent reaction is that a current Web 3.0 agenda is about 15 years too late (Metz, 2007). Again, we agree to the extent that many of our colleagues have spent years exploring technological innovations afforded by Web 3.0. For instance, there is cutting-edge work being done in education with artificial intelligence (Porayska-Pomsta, 2016), Internet-of-Things (Maksimović, 2018), machine learning (Kosko et al., 2021), and even the Metaverse (Jeong et al., 2021). There are also specific cases from the field. An example is Michele Lee (@MsLeeTeacher), a teacher from River Bend School District in Raleigh, North Carolina. Michele uses NFTs, cryptocurrency, and the Metaverse to teach students and get them interested in blockchain technologies. Students not only meet teaching and learning standards, but they also learn skills that help them to start managing their own art, music, and finance-related portfolios. A second exemplar is Bill Moore (https://rewildgame.toonstech.com/), who is attempting to use the blockchain to incentivize environmental conservation of the American bison. The gameplay allows players to use augmented reality to capture and breed bison. Successful players practice rewilding of the Great Plains while they earn both bison NFTs and NCKL crypto tokens on the *Cardano* blockchain. For the record, while both have been successful, neither learned these techniques and strategies in preservice or inservice teacher education.

These examples notwithstanding, Web 3.0 is still in its early stages, particularly for education generally and teacher education specifically. However, Web 3.0-based technologies are now more quickly gaining adop-

tion in the public and commercial spheres—a move that provides impetus for educators to reconsider their roles in adoption and uptake. The purpose, therefore, of this call to action is to urge teacher educators (those in preservice teacher education and in-service professional development) to consider or reconsider the ways in which teacher education may not be keeping up with the rapid-advancing changes in the move to Web 3.0. This article begins with a brief introduction to the basic tenets and concepts of Web 3.0. It then addresses why teachers—and, therefore, teacher educators—should care about this topic. The paper concludes with recommendations and next steps for teacher educators and teacher education researchers.

BASIC TENETS OF WEB 3.0

To fully consider Web 3.0, it is important to understand the versions that preceded it. The Internet is constantly evolving to meet the needs of users; the technical capacities and capabilities evolve and scale. Web 1.0 "users could only browse, read and retrieve information" (Ohei & Brink, 2019, p. 1842). Websites were informational and purely designed to consume information and provide access to a completely new audience. Web 2.0—also known as the social web (Gurunath & Samanta, 2022)—was read and write, which ushered in the social media period of the Internet that we benefit from today. What started with *GeoCities*, message boards, *LiveJournal*, and *Myspace* has now evolved to *Facebook*, *Twitter*, *TikTok*, *Instagram*, *YouTube*, and *Reddit*. This period was empowering because it gave users the ability to create content, build community, and provide an environment for people to thrive on the Internet.

The one obvious challenge with Web 2.0 is ownership. You do not own your content; the social media companies do. They decide and dictate who can see your content, how you manage it, and even if your content is accessible at all. What is potentially even more dangerous is that this ownership is often managed not by a team of content experts and evaluators, but by algorithms and automation that is prone to error and bias. There have been high profile examples of censorship by tech company leadership such as Twitter's banning of Donald Trump while he was a sitting US President (Alexandre et al., 2021). However, most of the real censorship or predictive engagement with content is driven by code, rather than political vendetta (Jaidka et al., 2022; Lazer et al., 2018).

Web 3.0—often referred to as the semantic web (Gurunath & Samanta, 2022)—changes this, in part, because it is decentralized. It gives ownership to users by allowing their data to travel with them between sites secured

and verified by the blockchain. As long as the site supports Web 3.0, users can connect their wallet and their digital assets, tokens, NFTs, and Metaverse wearables. This theoretically means data is safe, censor-resistant, and portable (Kim, 2021). Balaji summarized that "Web 3.0 comprises a set of tools involving markup data, crowd-sourced content, data mining and machine learning to enhance intelligence, underlying frameworks and architecture of the Web toward establishing semantic connections, so that machines understand and interpret what humans exactly want – contextual, relevant results" (Balaji et al., 2018, p. 13). Technologies that are built upon this blockchain could include augmented and virtual reality, virtual worlds (e.g., Metaverse), cryptocurrency, NFTs, machine learning, AI, intelligent tutoring agents, and big data (Dominic et al., 2014).

Web 3.0 is not without its challenges. For instance, outside of the relatively slow speed of innovation adoption in education, we are at the early stages of adoption globally. Moreover, there are arguably conflicts between societal and/or cultural norms that are currently at odds with both decentralization and the technical processes and functions that will allow for blockchain and Web 3.0 utility to be efficient, simple and user friendly, and environmentally conscious. These challenges notwithstanding, Web 3.0 has the potential to dramatically impact teaching and learning (e.g., Firat & Firat, 2020).

WHY TEACHERS AND TEACHER EDUCATORS SHOULD CARE

Research has consistently highlighted that, at the school level, teacher quality is one of if not the most significant influencers of student achievement (Hanushek, 1992; Rice, 2003; Rivkin et al., 2005). Other studies have highlighted the importance of teacher preparation for both improvement of teacher quality and increasing adoption and sustained use of traditional and emerging technologies (Darling-Hammond, 2000; Davis et al, 2009; Hennessy et al., 2007). Thus, while the importance of teacher quality and the role of teacher educators in impacting teacher quality are settled issues, there are at least three reasons that both teacher and teacher educators should consider innovative and robust activities for supporting the integration of Web 3.0 into teaching and learning: 1) the need to prepare students and teachers for a future that is already upon us, 2) addressing emerging issues related to ownership (i.e. intellectual property) and the validating, assessing, and managing of earned content and credentials, and 3) the evolution of Pedagogy 3.0. Each of these will be explored further in the following section.

The Future is Now

Web 3.0 isn't coming one day; it is already upon us. NFTs, blockchain, machine learning, artificial intelligence, cryptocurrency, the Internet of Things, and truly virtual worlds (i.e., Metaverse) have already begun to reshape the marketplace like never before. The labor market is no exception to this change as future employment opportunities, work experiences, and even compensation practices are likely to look dramatically different in the near future (Chunmian et al., 2021). Further, while educators grapple with evaluation of trends, fads, and distractions of Web 3.0, their students are being introduced and educated on this new evolution of the Internet via TikTok, social media influencers, celebrities, and others looking to take advantage of ignorance and inexperience. It is in this emerging new reality that the role of the teacher becomes critically important (Huk, 2021).

Moreover, if it is the responsibility of the teacher to prepare students for society, college, and career, then they simply cannot ignore the shifting landscape. As the conventions of our society and economy dramatically shift, teachers should engage by identifying ways to help students acquire and apply Web 3.0 skills and utilize the tools to further facilitate deep learning. Doing so will ensure that educators are effectively preparing students to enter college and career equipped with the skills and confidence necessary to proactively engage their work and studies in the modern age and the inevitable emergence of Web 3.0 as an evolving presence in teaching and learning (Chaveesuk & Suaysukvicha, 2021).

This challenge is not new to veteran teachers who have adjusted to such world-changing innovations as the Internet, Web 2.0, and one-to-one computing. As with those innovations, teachers must engage with Web 3.0 as it has the potential to dramatically improve the learning experience for all students. In order to fully realize this opportunity, teachers must be intentionally prepared in both the understanding of these technologies and the best practices for integrating their use into teaching and learning. From preservice teacher preparation in teacher education programs to both formal and informal inservice professional development opportunities, teachers must be equipped to be able to effectively prepare their students for a Web 3.0-enhanced future. It is from these basic Web 3.0 foundations that innovative teachers will find new, exciting, and effective ways to improve student learning, identifying best practices, and creating the examples that drive teacher improvement initiatives for years to come. The projected life and work of our students is always changing, but innovative teachers engage with technology in order to prepare students for success in that uncertain future.

Content and Credential Ownership, Assessment, and Management

With the emergence of increasingly diverse credentialing mechanisms, such as micro-credentials, badges, and certifications, levels of achievement have become increasingly blurred. While such credentialing mechanisms provide snapshots into achievements, knowledge, and skills, these often include vague and limiting descriptors. Additionally, there are a myriad of decentralized products that support management, validation, and assessment of such credentials, resulting in difficulty in sharing achievements and credentials across platforms. Web 3.0 affordances, such as blockchain technologies, can serve as an infrastructure to provide a permanent, centralized, portable, and reliable method of storing, validating, managing, and authenticating both content and credentials developed and earned via diverse formal and informal experiences (Jirgensons & Kapenieks, 2018). Further, such tools allow for documenting more diverse, personalized, and relevant learning experiences and more comprehensively illustrating one's lifelong learning path by illustrating continued growth in knowledge, skills, and disposition (Jirgensons & Kapenieks, 2018). While still relatively in its infancy and issues of scalability, security, and privacy exist, the potential for a more flexible and robust infrastructure to document, validate, and manage achievements provided by blockchain and other Web 3.0 technologies is already being explored by institutions of higher education, and will likely expand to K-12 environments in the near future. Thus, teachers and teacher educators should be aware of the various implications of such expansion and ways the tools can support various aspects of teaching and learning.

Pedagogy 3.0

Since the initial introduction of the Internet to the world, a constant evolution, from Web 1.0 to Web 2.0 and now to Web 3.0 has impacted teaching and learning. Consequently, as this evolution has occurred, teachers and teacher educators (albeit often begrudgingly and slowly) have shifted teaching and learning practices from the teacher-centered pedagogical practices often associated with Web 1.0 (Pedagogy 1.0) to the more participatory and student-centered Web 2.0 (Pedagogy 2.0) instructional practices (Jimoyiannis et al., 2013). As the evolution to Web 3.0 is upon us, teachers and teacher educators must now shift to the more personalized, individualized, portable, interoperable, explorable, and validation/management nature of Web 3.0-enhanced pedagogical approaches (Ohei & Brink, 2019). Thus,

with Pedagogy 3.0, student-centered instruction is extended from Pedagogy 2.0 in that learning is more self-regulated and directed, with both teachers and learners leveraging Web 3.0 tools to organize their learning, develop goals, and establish more personal and relevant learning paths (Chisega-Negrilă, 2013; Firat & Firat, 2020).

Further, teachers now have a unique opportunity in Web 3.0 that (at least as an industry) was not taken advantage of in Web 2.0. With the emergence of the multi-functional and multi-tool aspects of Web 3.0, educators need to leverage their unique abilities to help break down complex ideas and present them in a way that is easily understandable. This is a large educational void in Web 3.0 (e.g., Ethereum.org, 2021); teachers would not only benefit their own students who are exploring the space, but they could impact others by serving as advisors and guides to the greater Web 3.0 ecosystem. When exploring the core of Web 3.0, connections can and should be made to currently curricular and educational standards. Further, once the ethos of Web 3.0 is understood and a strong grasp of decentralized ownership is established, educators can then explore the technical process and utility of Web 3.0. Educators can serve as trusted guides and advisors to discuss this technology, explore ways to practice Web 3.0 processes, and prepare students to venture into this new Internet safely and responsibly. Teachers need to work with the Web 3.0 community to understand the complexities of blockchain, NFTs, tokens, and other Web 3.0 tools allowing for both teachers and learners to enter into the Web 3.0 world in new and meaningful ways.

PRACTICAL RECOMMENDATIONS FOR TEACHER EDUCATION RESEARCH AND PRACTICE

Arguably Web 3.0 is still in its early stages of adoption (Ragnedda & Destefanis, 2019). Moreover, there are varying technologies that are built upon the Web 3.0 infrastructure (Horban et al., 2021). Finally, while there are some empirical studies in the area (e.g., Firat & Firat, 2020), more research is needed to fully understand its impact and potential role in teacher education (i.e., the purpose of this call). Given this background, it can be difficult to provide an easy next step for inservice or preservice teacher educators. It is not as simple as suggesting, for instance, that someone go and read a single paper or learn a specific new tool. This complexity notwithstanding, there are at least four recommended next steps.

The first three recommendations are adapted from a paper on Web 3.0 and higher education written by Ohei and Brink (2019). In their article, they

clearly identified institutional and educator barriers to Web 3.0 adoption. First, they suggested that institutions lack accessibility to technological resources, technical support, operational training, and time for faculty to learn about Web 3.0. An obvious next step is to begin conversations with departments, schools, and colleges about preparedness and readiness for the move to Web 3.0. Our individual experience is that while the term may be recognizable, faculty and administration are often unclear about the pedagogical or technological implications of the move from 2.0 to 3.0. Initiating conversations can be an excellent way to inform and discuss future support. Additionally, while there are educational applications of Web 3.0, the semantic web has broader reaching applications beyond teacher education. It may be necessary and fruitful, therefore, to also reach across colleges to learn what faculty or staff in other areas are doing (e.g., educational psychology, computer science, business, design).

Ohei and Brink (2019) also acknowledged that the educator plays a role. This can come in the form of confidence and/or resistance. While the authors recognized that both confidence and resistance are impacted by institutional factors (e.g., lack of support), they stated that "educators' attitudes towards the use of new technological tools in education remain an obstacle for Web 3.0" (p. 1844). They added that "a positive attitude leads to engagement/commitment behaviours, while the negative attitude leads to resistance or avoidance" (p. 1844). A second recommendation, therefore, is to reflect on one's willingness to learn more about Web 3.0, its potential impact on pedagogy, and new technological innovations it might offer teaching and learning (Murray et al., 2022). If a teacher educator (preservice or inservice) is not willing to be challenged by new ideas, it seems dubious that they would expect their students to do the same.

Third, Ohei and Brink (2019) recognized a limitation in educator competence (p. 1844). Teacher educators should respond, therefore, by attempting to consume as much information as possible. This could include articles in and outside of teacher education (e.g., Firat & Firat, 2020; Horban et al., 2021; Jensen, 2019; Jirgensons & Kapenieks, 2018; Murray et al., 2002). This should also include practitioner and pop press articles or videos given how little research has been currently published on the topic (e.g., Bhattacharya, 2021; Ethereum.org, 2022; Leppington, 2022; Whiteboard Crypto, 2021). Finally, teacher educators could conduct searches to examine or explore specific technologies within Web 3.0 infrastructure, including but not limited to blockchain technologies (e.g., Jirgensons & Kapenieks, 2018), cryptocurrency (Rooksby & Dimitrov, 2019), non-fungible tokens or NFTs (Elmessiry et al., 2021), decentralized autonomous organization or DAO

(Hsieh et al., 2018), the Metaverse (Hirsh-Pasek et al., 2022), and artificial intelligence (Hao, 2019).

Last, but not least, good pedagogy encourages students (and teachers) to be producers and not just consumers of innovative ideas and tools (e.g., Ferdig, 2006). Therefore, teacher educators should be encouraged to begin to play with Web 3.0 technologies. This could include the creation of cryptocurrency coins or tokens (Binance Academy, 2022). They could also consider introducing preservice or inservice teachers to existing cryptocurrency and blockchain curriculum aimed at students as early as Kindergarten (BitIRA, 2019). Educators could explore NFT marketplaces (e.g., *OpenSea* - https://opensea.io/; *SuperRare* - https://superrare.com/ and galleries (e.g., *B.20* - https://b20.metapurse.fund/; *KnownOrigin* - https://knownorigin.io/), or consider creating (and have students create) art-, music, or photography-based NFTs (Vasile, 2021). Adventurous souls might event consider entering the Metaverse (Sensorium, 2021)--with or without virtual reality headsets–to play a game or meet new friends (Trahan, 2022).

CONCLUSION

There are several limitations to Web 3.0; Ethereum.org (2022) describes education as one of the main ones. The website specifically notes:

> *Web3 introduces new paradigms that require learning different mental models than the ones used in Web2.0. A similar education drive happened as Web1.0 was gaining popularity in the late 1990s; proponents of the world wide web used a slew of educational techniques to educate the public from simple metaphors (the information highway, browsers, surfing the web) to television broadcasts. Web3 isn't difficult, but it is different. Educational initiatives informing Web2 users of these Web3 paradigms are vital for its success.* (N.P.)

Arguably they are contextualizing education as a means to support widespread adoption of Web 3.0, not simply the use of it in Pre-K-12 to postsecondary teaching and learning environments. Their warning, however, is apropos for the next steps for teacher education, in addition to the practical implications already mentioned. First, we need teacher educators who are willing to explore the development, implementation, and evaluation of Web 3.0 technologies and pedagogical strategies. The *Journal of Technology and Teacher Education* (along with other AACE journals; https://www.aace.

org/pubs/) is interested in publishing research on such experimentation. Second, we need teacher educators who are willing to step outside of traditional field boundaries to collaborate and then publish with those who may already be working in and with Web 3.0 technologies. Such steps will be critical in helping prepare future teachers and students for a decentralized web.

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