Educational Technology and the Pre–K–12 Environment: Implications for Education Leaders, Teachers, and Students

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INTRODUCTION

"More than 65% of children entering primary school today will ultimately end up working in completely new job types that do not yet exist" (World Economic Forum, 2016, p. 3). Today's Pre-K-12 students need to develop the college and career readiness skills that will enable them to be successful in the technologically driven jobs of the future. "To be successful in their lives beyond school, students need to develop skills and abilities that enable them to become proficient creators, collaborators, communicators, and critical thinkers" (Grimes & Cohen, 2022, para. 3). The Partnership for 21st Century Learning (P21) refers to these skills as the 4Cs: creativity, collaboration, communication, and critical thinking (Battelle for Kids, n.d.). Additionally, Pre-K-12 students will need to have advanced technology skills to be problem solvers, content creators, and multi-taskers as they work on complex and multi-faceted projects. The best way that today's students will be prepared for the jobs of tomorrow is if Pre-K-12 teachers engage in the use of digital learning tools across all content areas in the Pre-K-12 curriculum.

Technological innovation over the past two decades has forever altered today's Pre-K-12 education landscape. "Revolutionary advances in information and communications technology (ICT)—particularly disciplines associated with computers, mobile phones, and the internet—have precipitated a renaissance in education technology (ed-tech), a term used here to refer to any ICT application that aims to improve education" (Escueta et al., 2017, p. 2). ICT and content-neutral technologies will empower Pre-K-12 teachers to change the way they teach their students throughout the 21st Century. Ed-tech tools range from the use of artificial intelligence, virtual reality, augmented reality, and apps to specific digital learning tools. Teachers and students in high-needs Pre-K-12 schools will require the greatest support to implement and use these existing ed-tech tools to foster digital equity in education. Additionally, schools and teachers will need support and innovative ideas for navigating remote instruction without universal internet access or devices for their students—particularly those in high-poverty schools in rural and urban school districts. The creation and use of ed-tech tools and apps that do not require internet access, or that could be downloaded while in a connected school environment, could be a start in creating more equity for all Pre-K-12 students attending schools in urban, suburban, and rural districts. States and individual school districts should seek out and review innovative ICT options and ed-tech tools to help teachers provide high-quality instruction even when internet access is not possible for students in their home environments.

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BACKGROUND

Content-Neutral Technologies in Pre-K-12 Teaching

For several decades, many scholars have argued that ICT as educational devices facilitate the adaptation of teaching to each student, even during the remote learning that took place during the COVID-19 pandemic. Some have indicated that this is because they can promote collaboration, interactivity, the use of multimedia codes, and greater control of learning by the learner (Collins & Halverson, 2010; Jaffee, 1997). When ICT are used in this way, their integration into the curriculum would contribute to the acquisition of 21st Century competencies (autonomy, collaboration, critical thinking, and problem-solving) that the Organization for Economic Cooperation and Development (OECD) (Ananiadou & Claro, 2009) links to "global competence" that should define current education throughout the world (Ertmer et al., 2015).

Content-neutral technology is multi-disciplinary and can be used across many subjects and content areas in the Pre-K-12 teaching environment. Content-neutral technologies include "communication and collaboration tools as well as web-based digital media, and these technologies increase students' access to information, ideas, and interactions that can support and enhance sense making, which is central to the process of taking ownership of knowledge" (National Council of Teachers of Mathematics, 2011, para. 1). Literature further suggests using content-neutral and content-specific approaches to technology integration in teaching content-based curricula in schools (NCTM, 2011). Content-neutral technologies include communication and collaboration tools and web-based digital media that are more open-ended and promote an inquiry environment while content-specific technologies promote prompting and meaningful subject knowledge (Harris et al., 2009; Lin et al., 1999; NCTM, 2011). The creation of a Pre-K-12 virtual classroom library or reading room can be an effective way to engage students in the subject matter that is being taught and can be done in a content-neutral or content-specific way. This can be accomplished using Google Slides and Bitmoji (Fuentes & Grimes, 2020; Van Pate, 2022). These virtual classroom libraries and reading rooms can be organized around author studies, by subject/topic, around genre studies, student reading levels/decodable text based on skill, and include stuffed animals or character rooms (specific to elementary levels only). Another content-neutral technology that can be used by teachers is digital binders and notebooks to assist students in note taking, essay writing, and creating checklists for project-based learning assignments.

Moving beyond the concept of virtual classroom libraries, reading rooms, and digital binders/notebooks, interactive instruction either live or self-paced can be implemented across grade levels and content areas through Google Slides with NearPod and PearDeck as well as by using Hyperdocs. Google Slides is a free presentation web application that includes nearly all the capabilities of a traditional presentation program such as Microsoft PowerPoint and offers the benefit of cloud storage (Computer Hope, 2021). A HyperDoc is a digital document—such as a Google Doc—where all components of a learning cycle have been pulled together into one central hub (Gonzalez, 2018). Within a single document, students are provided with hyperlinks to all of the resources they need to complete that learning cycle (Gonzalez, 2018). In addition, virtual wall displays on a Google slide classroom can serve as an effective way to engage students in phonics (consonant and vowel sounds), vocabulary words, as well as engaging in anchor charts or displays. There are myriad ways to recreate the physical classroom into a virtual classroom environment appropriate for Pre-K-12 students.

To encourage student participation in the virtual classroom environment, Pre-K-12 teachers should consider implementing a classroom management reward/incentive system. One way this can be done is through supporting and encouraging students' engagement in the remote learning environment. This reward/incentive system is backed by the implementation of the Positive Behavioral Interventions and Supports (PBIS), a 3-tiered behavior management system (Center on PBIS, 2022) and can use digital stickers, dollars, tickets, certificates and even include a virtual or in-person award ceremony.

SOLUTIONS AND RECOMMENDATIONS

Use of Content-Specific and Content-Neutral Technologies in Pre-K-12 Education

Technology in education should be both content-specific and content-neutral. Content-specific technology means that the technology is specific to the subject area (e.g. English Language Arts) that is being taught. Content-neutral technology is multi-disciplinary and can be used across many subject and content areas as well as across grade levels. It includes communication and collaboration platforms, which can help students share knowledge, work cooperatively with others, provide feedback to their teacher, and ask questions remotely. The benefit of using content-neutral technologies is they encourage students who are otherwise hesitant to participate in a live classroom discussion, as well as students who learn better visually rather than auditorily, to become more engaged in the learning process (SchoolMart, 2017). Traditional learning does not always encourage teamwork, but online social media-style learning platforms create bridges to link students of different learning styles and abilities, allowing them to work together virtually to solve problems, find solutions, check answers, and encourage one another to succeed (SchoolMart, 2017).

Content-neutral technologies should be used in all Pre-K-12 schools, especially in America's high-needs schools. Most high-needs schools are in urban educational settings, which make up 29% of the student population in the United States today (National Center for Education Statistics, 2013). The five largest urban and high-needs districts in the United States are the New York City Public Schools, Los Angeles Unified School District, Chicago Public Schools, Miami-Dade County Public Schools, and Clark County Public Schools (National Center for Education Statistics, 2019). High-needs schools also exist in many rural areas (Monk, 2007). A growing teacher shortage, especially in high-needs urban and rural schools and in fields like special education, is becoming a pressing concern for the United States and many other countries (Gorard et al., 2007; Guarino et al., 2006; Ingersoll, 2001; White & Smith, 2005). Content-neutral technologies hold the potential to help teachers in high-needs schools create a more equitable learning environment and provide technology-rich experiences for their Pre-K-12 students. Resilience strategies for new teachers, such as help-seeking, problem-solving, managing difficult relationships, and seeking rejuvenation/renewal, are key to supporting the success of teacher practitioners, especially in their first few years (Castro et al., 2010). Content-neutral technologies can enhance the teaching and resilience strategies of teacher practitioners and help with teacher retention, particularly in high-needs schools.

Educational Technology During the COVID-19 Pandemic

During the COVID-19 pandemic, teachers in high-poverty schools were more likely to report that their students lacked internet access at home. "Only 30% of teachers in high-poverty schools reported that all or nearly all of their students had access to the internet at home, compared with 83% of teachers in low-poverty schools" (Stelitano et al., 2020). Clearly, the digital divide affected marginalized students in high-needs schools at a far greater rate than students in all other types of schools. Even having access to the best ed-tech tools while in a school environment does not guarantee that students in high-needs schools will have access to those same tools in the home environment (Stelitano et al., 2020).

Prior to the COVID-19 pandemic, most professional development opportunities centered on technology for Pre-K-12 teachers focused on supporting face-to-face instruction in a traditional classroom setting (Liao et al., 2017). Furthermore, much of the research and implications for educational technology over the past 20-plus years centered on face-to-face instruction in the traditional classroom setting. In the last few years, because of the COVID-19 pandemic, education researchers were given their first opportunity to research and assess teachers and students' remote teaching and learning experiences (Hebebci et al., 2020; Onyema et al., 2020). Providing instruction to Pre-K-12 students in a remote learning environment during the COVID-19 pandemic was unprecedented and extremely challenging for Pre-K-12 teachers (Carrillo & Flores, 2020; Ferdig et al., 2020). Additionally, students in predominantly low-income schools and in urban locations suffered learning loss at higher rates during the pandemic than their peers in high-income rural and suburban schools (Dorn et al., 2020). As a whole, low-income families were less likely to have access to the technology required to fully participate in online learning (Polikoff et al., 2020; Stelitano et al., 2020) and their parents were more likely to be essential workers (Berube & Bateman, 2020), with less time to devote to their children's online learning experiences. Both parents and their children were overwhelmed throughout the course of the COVID-19 pandemic. Minority students might also have been disproportionately affected due to existing racial inequalities in Pre-K-12 school spending (Sosina & Weathers, 2019) and unequal access to high-quality teachers trained in the use of digital tools and educational technology (Clotfelter et al., 2005; Goldhaber et al., 2015).

A systematic review of literature regarding K-12 online teaching and learning in the United States was conducted to inform the work of policy makers, researchers, teacher educators, teachers, and administrators, as they negotiated the changing role of online instruction in our nation's educational systems (Johnson et al., 2022). The review revealed a set of contextual conditions that are foundational to student learning in K-12 online settings. These contextual conditions included prepared educators, technology access and autonomy, students' developmental needs and abilities, and students' self-regulated learning skills (Johnson et al., 2022). The literature also pointed to seven pillars of instructional practice that support student learning in these settings including evidence-based course organization and design, connected learners, accessibility, a supportive learning environment, individualization, active learning, and real-time assessment (Johnson et al., 2022).

Digital learning platforms have become central to communication, social interaction, and participation in contemporary societies. While many schools and districts continue to use other learning management systems, such as Blackboard, Canvas, Moodle, and Schoology, Google Classroom use has increased widely in recent years as a learning management system used by K-12 schools and teachers. Launched in August 2014, Google Classroom has grown to be used by a majority of K-12 schools and teachers across the United States (Education Week, 2017). Further, Google Chromebooks are currently the number one selling device in the United States, Canada, Sweden, New Zealand, and the Netherlands for the K-12 community (Mainelli & Marden, 2015). Google-powered Chromebooks, enabled with Google Classroom, have streamlined the way that Google and its many applications are used in the K-12 environment. For example, in August 2016, a guardian summary feature was added that allows parents to receive updates on students' work, missing assignments, or classroom announcements. Additionally, in 2021, Google rolled out over 50 updates for Classroom, Meet, and other online education tools (Perez, 2021). In future years, improvements are expected to continue to be made in Google Classroom as its usage continues to grow in the Pre-K-12 community across the United States and the world (Perez, 2021).

Perotta et al. (2021) presents a conceptual framework and an original analysis of Google Classroom as an essential infrastructure for pedagogy. Furthermore, Google for Education (which includes Google Classroom) can connect Pre-K-12 schools and districts with over 4000 experts globally through their education directory (Google, 2023a). This certainly will continue to influence Pre-K-12 school leaders and teachers using Google Classroom and Google for Education throughout the United States and many other countries in the world.

Many districts in America and throughout the world before and after the COVID-19 pandemic have used Google Classroom as a means of providing a virtual learning environment beyond the traditional physical classroom-learning environment. As a result of the pandemic, and the proliferation of Google products in U.S. K-12 schools, many K-12 teachers have turned to Google Classroom as a means of recreating traditional classroom settings in a digital learning environment (Bryant et al., 2022). At the onset of the pandemic, teachers had to deliver instruction virtually as a result of school closings and learning shifting to the remote learning environment. The vast majority of K-12 schools and districts in the United States asked teachers to turn to Google Classroom in support of their teaching and learning. Unfortunately, disadvantaged or low-income families in high-needs schools could not afford the broadband access needed for students' online learning experiences in the home environment, which has created a digital divide that continues to affect communities of color at a disproportionate rate (Auxier & Anderson, 2020). Internet and broadband access will continue to be an issue of equity in education until it is addressed by government at the federal, state, and local levels in the U.S., as well as by governments throughout the rest of the world.

The movement for school districts across America to provide a 1:1 ratio of one laptop or computing device per student was accelerated with the shift to full remote instruction due to the COVID-19 pandemic. School districts and schools were finally given the necessary funding to help to implement 1:1 computing so that teaching and learning could continue throughout the course of the pandemic. By its definition, "1:1 computing" refers to "the level at which access to technology is available to students and teachers" (Bebell & O'Dwer, 2010, p. 6). The definition; however, fails to say anything about the importance of educational practices or use of educational technology and digital learning tools. Access to the individual computing devices and the use of educational technology is the first step to studying or measuring any educational impact that the educational technology would have over time on instructional practices (teaching) and student achievement (learning) (Norris et al., 2003; O'Dwyer et al., 2004). To further support 1:1 initiatives in schools, Digital Promise created a Device Rollout Toolkit (Verizon, 2022) which shares best practices from Verizon Innovative Learning Schools (Doersch, 2022). The Toolkit can help support students, staff, and families throughout the school year. Moving beyond what was learned while teachers and students engaged in remote learning during the COVID-19 pandemic, it is clear that districts and schools with 1:1 computing with trained teachers in the use of educational technology and digital learning tools or apps will give Pre-K-12 students the greatest opportunity to learn.

Importance of TPACK and TIPC Frameworks in Technology Integration

As technology has advanced, various constructs and models have been advanced as ways to conceptualize teachers' use of technology and how they learn to integrate technology with instructional content and pedagogy. The Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Kohler, 2006; Shulman, 1986) was established as a way to frame efforts aimed at developing the knowledge and skills related to technology integration. TPACK provides a neutral and unbiased way of examining teachers' knowledge and skills related to teaching with technology without favoring specific learning theories or instructional practices (Misra & Kohler, 2006). Swallow and Morrison (2021) address the importance of TPACK and the 4Cs: critical thinking, communication, collaboration, and creativity when it comes to technology integration by teachers across content and grade levels. Niess and Gillow-Wiles (2021) address the importance of developing teachers' knowledge for teaching in a virtual context using TPACK. While the TPACK framework is widely used by teachers today, some scholars have cited skepticism in its use (Brantley-Dias & Ertmer, 2013; Kopcha et al., 2014).

There are clear elements of effective in-person instruction that carry over into virtual instruction such as establishing relationships, clarity of instruction, student engagement, and assessment practices (Fisher et al., 2021) when integrating content-neutral technologies in the virtual environment. Teachers need to be supported in how to organize virtual learning through high-quality instructional planning. This can be accomplished through the use of the Technology Integration Planning Cycle (TIPC) (Hutchinson & Woodward, 2014, 2018). TIPC was originally designed to help teachers as they sought to integrate digital tools into their in-person instruction. Now, TIPC, which is grounded in the TPACK framework (Mishra & Kohler, 2006; Shulman, 1986), supports teachers in selecting tools for digital learning and virtual instruction. The TIPC model is comprised of seven elements that support teachers as they plan instruction that integrates technology to instructional goals. The seven elements are: instruction goals, instruction approach, digital tool, contributions to instruction, constraints, and planning instruction (Woodward & Beschorner, 2021). Karchmer-Klein (2020) noted that instructional design must be at the forefront of collaborative and interactive online learning that is present in the TIPC framework. Although teachers' access to digital tools and resources for purchasing them varies widely, there are several free and low-cost digital tools that could be used for a variety of instruction purposes. However, the number of options for interesting new digital tools to use can be overwhelming for teachers, at times (Schwartz, 2020). This is why there is a need for Pre-K-12 teachers to engage in Technological Play Theory (Byker, 2017) to alleviate their stress and anxiety when it comes to using any of the many existing digital tools that are available to be used in the current educational environment.

Creating a Sense of Belonging in the Online Learning Environment

Integrating technology into instructional content and pedagogy also requires creating a sense of belonging for Pre-K-12 students in the online learning environment. Garrison et al. (1999) introduced the Community of Inquiry (CoI) construct as a way of understanding students' sense of belonging. This construct consists of three interrelated concepts: social presence, cognitive presence, and teaching presence, along with the interplay between them to characterize the online educational learning experience. For students to be successful in this type of environment, they must be highly self-regulated and motivated (Garrison & Cleveland-Innes, 2005; Garrison et al., 1999). However, many younger students do not yet have the skills to navigate the distance-learning (remote) environment without the support of a parent, guardian, or adult (Gillow-Wiles & Niess, 2021). One way to create a sense of belonging in the online learning environment can be accomplished by using Google Slides and Bitmoji (Fuentes & Grimes, 2020; Van Pate, 2022). The more students feel comfortable and connected to the online learning environment and their classroom teacher, the more likely they will be to be engaged in their virtual learning experiences. Creating a sense of belonging for Pre-K-12 students may even involve teachers creating an online virtual learning space that supports the needs of individual, small group, and whole class learning experiences in an ongoing manner.

FUTURE RESEARCH DIRECTIONS

Educational Technology: Moving Forward

Pozo et al. (2021) provides definitive research as to the lessons learned from the uses of digital technologies during school lockdowns throughout the COVID-19 pandemic. Among the lessons learned from their research study were that the proposed activities varied depending on the learning being promoted (reproductive or constructive), the learning outcomes (verbal, procedural, or attitudinal), the type of assessment to which the activities were directed, and the presence of cooperative activities. Teaching remotely during the pandemic taught a valuable lesson to all educators across the United States and the world. That lesson was that school administrators, teachers, and librarians need to have the necessary technology skills to support learning and provide access to learning resources in today's Pre-K-12 classrooms, libraries, and schools. Post-COVID-19 pedagogy requires Pre-K-12 school administrators, teachers, students, and families to become familiar with various digital technologies used in and out of schools to promote in-person as well as distance (remote) and virtual learning. District and school administrators need to have the necessary understanding of the ISTE Standards framework and the role that technology will play in the Pre-K-12 learning environment in 21st Century teaching and learning. To assist administrators and teachers in understanding how the ISTE Standards framework connects with teaching, Dousay (2020) presents an integrated map of the ISTE Standards for Educators while making the connections to the Danielson Framework for Teaching, and the Interstate Teacher Assessment and Support Consortium (InTASC) Standards. Case study findings from Miller (2022) include how pre-K-12 school administrators can benefit from the ISTE Standards' framework to provide future-ready learning environments, how the standards serve as a technology guide to increase equity, inclusion, and digital citizenship, and how school leaders benefit from participating as co-learners.

In June of 2022, the U.S. Department of Education and the International Society for Technology in Education (ISTE) (Brooks-Young, 2016) began pressing colleges of education across the United States to publicly commit to better preparing future teachers, librarians, and administrators to be good consumers of technology in order to support the learning needs of today's students. As part of this commitment, teacher preparation programs nationwide are being called on to sign a pledge, called the Digital Equity and Transformation Pledge. This reflects the increasing urgency for colleges to better prepare future Pre-K-12 educators, librarians, and school administrators for the evolving technology needs in America's schools. "Knowing how to use technology to support student learning is an essential skill for teachers to thrive in a post-COVID world," according to ISTE CEO Richard Culatta (Fittes, 2022).

While it is hard to predict the future of teaching and learning in the 21st Century, many education leaders expect K-12 school districts to continue their investment in classroom technology and ed-tech tools. Overall, worldwide technology in the education market is projected to reach $285.2 billion by 2027 (Grand View Research, 2021). School administrators, teachers, and librarians should provide a transformative education to their students, which provides the necessary college and career readiness skills to meet the needs of future jobs and industries that are currently being driven by technology.

Unfortunately, all across the United States distance learning models have had the unintended consequence of increasing achievement gaps in schools. This can be attributed to the existing digital divide, which increased in the Pre-K-12 environment by the forced move to remote instruction in March of 2020 (Dorn et al., 2020; Norris, 2003). As stated previously, high-needs schools in urban and rural areas across America were impacted more than other schools during this time. The desire to meet the needs of today's digital learners can lead to Pre-K-12 school administrators, teachers, and librarians earning ongoing micro-credentials in the latest ed-tech tools and digital pedagogies that empower student learning. Micro-credentials have become an emerging approach to teachers' professional learning where individuals earn a digital certification upon completion of competency-based course objectives (National Education Association, 2022). They allow teachers to learn new skills and develop competencies in several subjects including STEM subjects, computer science, and other content areas in an ongoing way.

Educators need to be lifelong learners to prepare students for higher education and their future careers. The National Education Association (NEA) currently offers over 175 micro-credentials (National Education Association, 2022) with many colleges and universities beginning to offer their own micro-credentials for Pre-K-12 teachers on topics such as character education and digital teaching (Tooley & Hood, 2020; Western Governors University, 2021). Teachers practice skills and are evaluated on discrete topics or practices by demonstrating competence before they are awarded micro-credentials by an individual organization or institution. Colleges, universities, and even companies like Apple, Google, and Microsoft (Apple, 2023; Google, 2023b; Microsoft, 2023) have embraced the movement towards developing specific and ongoing professional development and/or micro-credentials to meet the needs of today's teachers and students in the Pre-K-12 environment. It is becoming more commonplace for Pre-K-12 teachers to become Google-certified. In terms of Google certification for Pre-K-12 educators, there are currently three levels: Google Educator Level 1, Google Educator Level 2, and Google Certified Trainer (Sowash, 2022). Each Google certification focuses on practical applications of Google products such as Gmail, Google Drive, and YouTube to be used in classroom settings (Sowash, 2022). School districts and school administrators will have to decide on the level of expertise required of its Pre-K-12 teachers. Sowash (2022) estimates that 60% of teachers in the United States are currently ready to pass the Google Educator Level 1 certification exam with the remaining 40% needing training, support, and encouragement as they build confidence and experience using Google Workspace for education.

Governments, schools, and families increasingly value technology as a central part of the education process and invest accordingly. Technological innovation over the past two decades has forever altered today's education landscape. ICT and content-neutral technologies will continue to empower Pre-K-12 teachers to change the way they teach their students in the 21st Century. Teachers and students in high-needs schools will continue to need the greatest support to implement and use the latest ed-tech tools. Teachers will need support and innovative ideas for navigating remote instruction without universal Internet access or devices for their students—particularly those in rural, high-poverty schools. States and school districts should seek innovative options and look to forming partnerships for professional development training in ed tech and digital learning tools with the 78% of colleges and universities in the United States where there are 1,206 teacher education programs that prepare all of our future Pre-K-12 teachers (Levine, 2007). Currently, there are 800 schools of education that are institutional members in the American Association of Colleges of Teachers of Education (AACTE) (AACTE, 2022). These partnerships should be formed with the schools of education at the colleges and universities that are also members of the AACTE. The partnerships can support current and future teachers in providing a high level of quality instruction to their students. Furthermore, partnerships with schools of education at college and universities can lead to the development and creation of teacher micro-credentials to meet the digital learning needs of today's students while exploring ed-tech tools that could be used with or without internet access.

AACTE member institutions as well as all colleges and universities with teacher education programs should also consider supporting pre-service teachers to become Google certified and helping current Pre-K-12 educators obtain their Google certification. Higher education faculty at AACTE member institutions should explore ways that traditional classroom pedagogies and learning experiences can be transferred to a digital learning environment using the latest ed-tech and digital learning tools. Additionally, school districts across the United States should look to the approaching merger of the International Society for Technology in Education (ISTE) and the Association for Supervision and Curriculum Development (ASCD) in January 2023, for future guidance in providing ongoing professional development and innovation in education. ISTE's CEO, Richard Culatta, believes that the merger will be beneficial in the long run, saying that "the conversations around effective use of technology and innovation and redesigning and rethinking education just can't be a separate conversation from how we are running and leading schools" (Young, 2022, para. 7)."

Today's Pre-K-12 educators create dynamic physical and digital learning environments providing access, equity, and experiences for Pre-K-12 students to think, create, share, and grow. Effective Pre-K-12 educators promote cultures of learning and the thoughtful and creative use of digital resources. The COVID-19 pandemic thrust Pre-K-12 educators into a situation where they needed to become experts in remote instruction and using digital tools. Furthermore, the pandemic indicated that today's Pre-K-12 educators needed to be able to teach in both physical and virtual learning environments using current ICT. To help support current and future Pre-K-12 educators learn how to use the latest ICT and digital ed-tech tools, the author recommends checking out the Cult of Pedagogy, a website created by Jennifer Gonzalez to support teachers engaged in learning about and how to use ed-tech tools (Gonzalez, 2023b). The Cult of Pedagogy contains a blog, podcasts, videos, and the option to purchase their annual edition of the Teacher's Guide to Tech, an encyclopedia of over 650 educational technology tools which are grouped into over 50 categories, including tools for assessment, note taking, parent engagement, interactive lessons, and much more (Gonzalez, 2023a). The 2023 Edition of the "Teacher's Guide to Tech" would benefit all education students and Pre-K-12 teacher practitioners as it first gives a description of what the tool does in clear, simple language, and then shows a screenshot of the tool in action, with a link to the tool's website and a play button that takes the student straight to a video showing how the tool works (Gonzalez, 2023a).

Governments, schools, and families increasingly value technology as a central part of the education process and invest accordingly. For all the challenges that came with COVID-19 school closures, they have been a windfall to the educational technology marketplace. According to the Learning Counsel, a research firm, "K-12 districts in the U.S. alone spent $35.8 billion in 2020 on hardware, software, curriculum resources, and networks, representing a more than 25% increase over 2019" (Paykamian, 2021, para. 1). While it is hard to predict the future of teaching and learning in the 21st Century, many education leaders expect school districts to continue their investment in teacher professional development, classroom technology, and digital ed-tech tools. In the coming years, emerging technologies like machine learning, big data, and artificial intelligence will continue to increase the range of available education products while speeding up the cycles of learning for students (Escueta et al., 2017).

Importance of Technological Play for Pre-K-12 Educators

Technology supports both teaching and learning. However, it must be carefully examined and evaluated to understand the extent it should be used with learners in Pre-K-12 contexts and learning environments (Brooks-Young, 2016; Ross, 2020). Students need to have access to and develop their technology skills at earlier grade levels than previous generations to be college and career ready. Technology is most effective when it provides students with opportunities to engage in activities that focus on higher order thinking skills over simple drill and practice activities (Freeman et al., 2017; Ross, 2020). Pre-service teachers and current Pre-K-12 educators need to focus on specific related processes when learning how to teach with technology (Kopcha et al., 2020) and need best practices/examples modeled for them by other educators (Polly et al., 2020, 2021; Polly et al., 2020; Tondeur et al., 2017). In addition, pre-service teachers and current Pre-K-12 educators need to have authentic opportunities to practice using new technologies to teach with support in low-risk environments (Tondeur et al., 2017, 2011). Modeling combined with opportunities for practice provides a "technological apprenticeship of observation" (Byker et al., 2018, p. 135) for pre-service teachers and current Pre-K-12 educators about the purpose behind the technology integration as well as the affordances and overall constraints of the technology. Technological Play Theory (Byker, 2017) serves as an instructive framework in supporting technological apprenticeship in teaching and learning. Overall, technological play can support and expand the capacity of pre-service teachers and teacher practitioners to utilize instructional technology for effective outcomes in their professional practice as Pre-K-12 teachers. Technological play can enhance the level of comfort and familiarity of the new ed-tech tool in implementation in the traditional physical or remote classroom environment. The purpose of using technological play theory with pre-service teachers and teacher practitioners would be to introduce them to Google Classroom, various education apps, and other digital tools in preparation for their student teaching and ongoing professional practice in the Pre-K-12 education environment.

The Metaverse: The Next Learning Frontier in Pre-K-12 Education

The metaverse is a virtual version of the real world that leverages artificial intelligence, augmented reality, virtual reality, and "Web3" to create immersive, 3-D, real-time, and interactive social environments (Driscoll, 2022). It is the next learning frontier and lives in a network of interconnected computers and includes a range of free, accessible, and decentralized games, communities, and venues for interaction. In the metaverse, anyone can join or create interactive digital spaces. Metaverse users can interact with each other in virtual spaces, build things (in groups or alone), play games, and interact with avatars and 3-D digital objects (Driscoll, 2022). Broadly speaking, the metaverse will enable students to learn in fully immersive and multimedia environments that leverage both the physical and digital worlds (Driscoll, 2022). The Tlili et al. (2022) study conducted a systematic literature review of the Metaverse in education. This study then applied both content and bibliometric analysis to reveal the research trends, focus, and limitations of this research topic with over 20,000 researchers viewing the findings of this study.

Currently, the metaverse only partially exists. There are existing online interactive worlds that provide a "metaverse experience," but these are not interconnected and provide only a limited social interaction. "The metaverse infrastructure is largely still under construction, with tech companies like Meta and gaming platforms like Roblox experiencing growing pains as they expand the space (Salman, 2022, para. 8)." Ed-tech companies like STEMuli, Labster, and even Roblox, offer VR learning experiences, but "no one as of yet is offering the kind of technology" that Glenn Platt, professor of emerging technology at Ohio's Miami University says "makes the metaverse really revolutionary" (Salman, 2022, para. 9). In a policy brief by Hirsh-Pasek et al. (2022), researchers explored how to bring the best educational practices into the metaverse as it is being created. Many experts believe the metaverse will become ubiquitous in the not-so-distant future.

Underlying metaverse technologies, including virtual reality (VR) and augmented reality (AR), have also been in use in education for some time. VR enables the creation of immersive learning experiences that can help enhance student understanding of a topic. VR enables users with VR headsets to become immersed in an array of real-world or fictional environments that allow students to experience virtual field trips and alternate realities. A recent PriceWaterhouseCoopers (2020) study found that VR learners could be trained four times faster than classroom learners and found that VR learners were more focused than basic remote e-learners. With AR, one can overlay images, videos, and sounds onto an existing environment to "augment" a real-world scenario. Living Popups Bookspace is currently using AR to create interactive and engaging literacy experiences for elementary, middle school, and high school students, where the illustrations in select titles will interact with students as they engage in reading (Living Popups, 2022). AR powered books developed by Living Popups Bookspace are meant to improve student engagement, comprehension, retention and test scores for students in the K-12 environment (Living Popups, 2022). This is just one example of many in how AR is being used in education. Beyond experiencing virtual immersive environments and augmented literacy engagement, VR and AR are being used to create more engaging and interactive learning experiences for Pre-K-12 students.

Artificial Intelligence

Roose (2023) believes that despite the risks that ChatGPT, a platform that uses artificial intelligence (A.I.) raises, schools should thoughtfully embrace ChatGPT as a teaching aid and as a digital learning tool that could unlock student creativity, offer personalized tutoring, and better prepare students to work alongside A.I. systems as adults. Artificial intelligence can improve Pre-K-12 education by creating more equitable learning outcomes for students in the United States. Overall, there are many benefits to using A.I. for students, teachers, and administrators. It can help to close learning gaps between students in lower-income schools and those in wealthier ones, as well as improve educational outcomes for all students. For students, A.I. can provide a personalized learning experience tailored to their individual preferences and needs, immediate feedback on their work, answers to their questions, and increased access to tutoring and other educational materials. For teachers, it can help automate some of their workload, design better interventions, and reduce burnout. For administrators, A.I. can monitor the student body and provide preemptive interventions with the help of predictive analytics (Diebold & Han, 2022). Researchers believe that the U.S. Department of Education should take the following steps to promote A.I. deployment and use:

- Develop a 10-year plan for A.I. in education, keeping in mind the challenges many schools face with limited digital capacity and resources, data quality, and stakeholder resistance.
- Develop A.I. grants to foster the adoption of A.I. in education and explore the creation of a model data-driven school district.
- Support A.I. product procurement for schools by strengthening information repositories that review A.I. products in education (Diebold & Han, 2022, p. 2).

Ultimately, A.I. can be used to support students in all subjects, but especially in the subjects of math and reading, given the recent low scores of American students on the 2022 Nation's Report Card, which was administered by the National Assessment for Educational Progress (NAEP). Students reached lows in these national achievement tests in the subjects of reading and mathematics not seen since the 1990s (National Assessment for Educational Progress, 2022; Sparks, 2022). Clearly, A.I. and other technologies will play a key role in advancing the educational achievement of students across America in the decades to come as it helps to individualize students' learning experiences as well as drive more equitable educational outcomes for America's schools. Educational technology will continue to shape and reshape the teaching and learning that goes on in America's Pre-K-12 schools and in schools all over the world now and well into the future.

CONCLUSION

Prior to the COVID-19 pandemic, most professional development opportunities centered on technology for pre-K-12 teachers focused on supporting face-to-face instruction in a traditional classroom setting (Liao et al., 2017). Polly et al. (2021) outlines for educators the future directions for K-12 technology-enhanced learning environments. Polly et al. (2021) believes that supporting teachers' capacity to teach with technology through collaboration and the sharing of expertise will result in positive outcomes for both Pre-K-12 teachers and students. Efforts to redesign schools have led to more opportunities for learner-centered models of education that are more compatible with distance learning (An & Reigeluth, 2011; Chou, 2004; Cullen et al., 2012; Lee et al., 2018; Reigeluth & Karnopp, 2013). These models have focused more on student learning and less on time spent in a classroom setting and are made possible by current ICT as well as technological and societal advances. Professional development that fits within the learner-centered models of education could cover setting up routines and digital technology tools for learning within a Pre-K-12 school environment during the beginning of the school year.

Future professional development should support teachers in helping students take better ownership of their learning using technology tools and resources (An & Reigeluth, 2011; Fancom et al., 2021; Reigeluth et al., 2016). A more blended learning approach requires school and district technology leadership to adopt open attitudes toward using ICT, digital learning tools, and digital resources so schools can be better prepared for academic continuity during future school closings in the post-COVID-19 era (Francom, 2021). Content-neutral technologies in pre-K-12 teaching and proven instructional practices hold the promise and potential of more robust teaching and learning experiences in the pre-K-12 environment for all schools now and well into the future. Technological Play Theory (Byker, 2017) will continue to serve as an instructive framework in supporting technological apprenticeship and expertise in teaching and learning as Pre-K-12 teachers embrace the idea of being lifelong learners and engaging students in more student-driven individualized learning experiences. Teachers seeking expertise in incorporating new educational technology into their professional practice may pursue micro-credentials offered through the NEA, their state education association, or from colleges and universities who are member institutions in the American Association of Colleges for Teacher Education (AACTE). AACTE member institutions who develop centers for digital learning and have experienced instructors using cutting edge ICT technologies to train pre-service and current Pre-K-12 teachers will have the greatest impact on the teaching profession and the 21st Century learning experiences of students.

As Pre-K-12 teachers in the United States begin to learn how to use new ed-tech digital tools, how to incorporate VR, AR, AI, and how to introduce the metaverse experience to students in their professional practice, they will begin to transform student learning experiences both nationally and internationally. While it is difficult to predict the future of teaching and learning in the 21st Century, many education leaders expect school districts to continue their investment in professional development, classroom technology, and ed-tech digital tools, as ICT continues to shape the skills and learning experiences of Pre-K-12 students on a national and international level, as they prepare to become college and career ready in order to meet the demands and specific needs of industry and the jobs of the future.

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KEY TERMS AND DEFINITIONS

Artificial Intelligence: The ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings.

Augmented Reality: Augmented reality is a system that enhances the real world by superimposing computer-generated information on top of it.

COVID-19: COVID-19 is the disease caused by SARS-CoV-2, the coronavirus that emerged in December 2019.

Digital Learning: The acquisition of knowledge or skills of a particular subject using technology.

Educational Technology: Digital technology used to facilitate learning.

Metaverse: A collective virtual shared space, created by the convergence of virtually enhanced physical reality and physically persistent virtual space, including the sum of all virtual worlds, augmented reality, and the internet.

Micro-Credentials: Short, competency-based recognition that allows an educator to demonstrate mastery in particular areas.

Pre-K-12 Teachers: Professional instructors who aid in the cognitive and social development of students from pre-school through 12th grade.

Professional Development: A wide variety of specialized training, formal education, or advanced professional learning intended to help administrators, teachers, and other educators improve their professional knowledge, competence, skill, and effectiveness.

TIPC: TIPC stands for Technology Integration Planning Cycle. It is a theory grounded in the TPACK framework that supports teachers in selecting tools for digital learning and virtual instruction as they plan instruction that integrates technology to instructional goals.

TPACK: TPACK stands for Technological Pedagogical Content Knowledge. It is a theory that was developed to explain the set of knowledge that teachers need to teach their students a subject, teach effectively, and use technology.

Virtual Reality: A simulated 3-D environment created with computer hardware and software that enables users to explore and interact with a virtual surrounding in a way that approximates reality, as it is perceived through the users' senses.