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In the Twilight Zone: K-12 Educators and Educational Technology in the Fourth Industrial Revolution

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Abstract— This paper examines the attitudes and perceptions of educators in the Southeastern United States regarding the integration of technology in education. Rogers's (1962) diffusion of innovations theory served as the theoretical framework for this study, as it allows for the examination of adoption elements and innovation diffusion. Rogers's theory established a concrete, usable framework for multiple research disciplines. The introduction of new technology does not guarantee a positive reception from educators. Prior researchers have indicated that although there is a desire to integrate technology, educators struggle with obstacles, including confidence, competence, and access. A significant contribution of this research is that it provides stakeholders and policymakers with a deeper understanding of educators' perceptions regarding the integration of technology. We view educational technologies as a precursor to Artificial Intelligence (AI) and the Fourth Industrial Revolution. Future research should closely examine the role of AI, including the attitudes and perceptions of educators, to gain a deeper understanding of its impact on education. Specific AI tools should be evaluated in consideration of educators' comfort levels and confidence in their usage. For most educators in the USA, the Fourth Industrial Revolution marks a twilight zone about educational technology as the reality of AI radically shifts the educational landscape and the role of teachers.

Keywords— Artificial Intelligence; educational technology; Fourth Industrial Revolution; Scaffolding.

INTRODUCTION

The use of technology within educational contexts is increasing across all content areas and at various educational levels (Fahimirad, 2018; Islam & Gronlund, 2016). Regarding educational technology, including Artificial Intelligence (AI), many educators show little knowledge or application of AI in the classroom (Elmansi, 2023; Das, 2024). Camputaro argues that less than ten percent of teacher education programs prepare teachers to use AI in the classroom (Camputaro, 2024). Data indicate that more than two-fifths of the workforce's skill sets, including those of teachers, will be outdated between 2025 and 2030 (World Economic Forum, 2025; Bouattoura, 2023). In this paper, we present the results of an interpretive phenomenological study on teachers' perceptions of educational technology and argue for the need for educators to integrate technologies applicable to teaching under Fourth Industrial Revolution conditions. Using Rogers' Diffusion of Innovations Theory, specifically its categories of Adoption, we argue that it is essential for policymakers to help teachers engage with AI and other technologies in education.

The use of technology in education has a long history, and inventors have often found ways to market their technologies to educational institutions (Alenezi, 2017; Kashyap et al., 2024). The 1940s and 1950s placed a

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greater emphasis on audiovisual instruction (Alenezi, 2017; Pelaez et al., 2022). Educators in the 1970s utilized educational technology for solving equation problems (Carliner et al., 2008). A literature review on educational technology overwhelmingly indicates that technology enhances students' learning. Teachers have long been encouraged to integrate new technologies, rather than reject them outright (Gentile et al., 2023).

One-to-one technological classrooms appeared in 1990 to enable device access for all students at all times (Islam & Gronlund, 2016). Penuel (2006) subsequently defined one-to-one instruction as using handheld devices with consistent wireless access. Fleischer (2012) emphasized the importance of equipment consistency, whereby all students retain the same device. Handheld devices are now prominent in classroom routines throughout Western countries (Hassan & Geys, 2016). Convenient accessibility and the need to comply with policy changes have increased the popularity of one-to-one devices (Peck & Sprenger, 2008). A primary purpose of accessible classroom technology is to enable students to develop modern skills, ultimately leading to 21st-century abilities (Peck & Sprenger, 2008; Richardson et al., 2013).

Educational Technology

One-to-one technological classrooms appeared in the 1990s to enable device access for all students at all times (Schwab, 2016; Islam & Gronlund, 2016). Penuel (2006) subsequently defined one-to-one instruction as using handheld devices with consistent wireless access. Fleischer (2012) emphasized the importance of equipment consistency, whereby all students retain the same device. Handheld devices are prominent in classroom routines throughout Western nations (Hassan & Geys, 2016). Convenient accessibility and the need to comply with policy changes have increased the popularity of one-to-one devices (Haziazi, 2021; Peck & Sprenger, 2008). A primary purpose of accessible classroom technology is to enable students to develop modern skills, ultimately leading to 21st-century abilities (Peck & Sprenger, 2008; Richardson et al., 2013).

Studies on one-to-one classrooms prior to 2016 were generally limited, focusing primarily on implementation and academic outcomes (Cho & Littenberg-Tobias, 2016; Islam & Gronlund, 2016). Common concerns included whether classroom integration of digital devices serves as best practice in meeting the varied needs of each student (Cho & Littenberg-Tobias, 2016). Educators have hesitated to adopt new digital methods, alternatively retaining traditional textbooks (Scheuerell, 2015). Aidinopoulou and Sampson (2017) found that educators are frequently uncertain about their ability to use technology to address standards, receive the necessary training time to learn how to incorporate technology into the classroom, and retain the required level of background knowledge necessary to make full use of technology with their students.

Most one-to-one classroom advocates support the potential of information access, discussion improvement, and opportunities for data-driven instruction (Ito et al., 2013). Additional research has pertained to student improvement in writing, problem-solving, and motivation (Bebell & O'Dwyer, 2010). Adequate one-to-one classroom implementation entails significant educator scaffolding in technical equipment and independent learning (Orlando, 2009). Educators may be required to learn new concepts and skills, as well as overcome negative perceptions toward technology (Sutherland et al., 2008). Following policy changes and the movement

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toward handheld devices, educators are increasing their efforts to create student-centered activities that incorporate technology use (Fahimirad, 2018; Bebell & O'Dwyer, 2010).

Cho and Littenberg-Tobias (2016) argued that the benefits of technology-rich classrooms are inflated. Few studies have shown positive results equating the use of handheld classroom devices with demonstrated educational outcomes (Fleischer, 2012). Falloon and Khoo (2014) found that students did not use devices for their original purpose, and student learning did not improve through technology. Other researchers (Bellur et al., 2015; Kuznekoff & Titsworth, 2013) have suggested that students, when using handheld devices, are more distracted than focused on classroom tasks, resulting in academic interference.

Policymakers have indicated that including new devices in classrooms will result in educator acceptance, followed by a turnaround in overall attitude (Cuban et al., 2001). However, Doron and Spektor-Levy (2018) found that previous administrative perceptions of immediate acceptance did not hold. The introduction of new technology in classrooms has resulted in both positive and negative educator mindsets (Doron & Spektor-Levy, 2018). Bebell and Kay (2010) and Doron and Spektor-Levy (2018) recommended providing professional development before implementing new technology into classrooms. Additionally, emerging classroom technology should align with personal and professional goals set forth by educators (Bebell & Kay, 2010).

Theoretical Underpinning

Rogers' Diffusion of Innovations Theory, specifically the categories of adoption, serves as the theoretical framework undergirding this study. Rogers's (1962) diffusion of innovations theory has been demonstrated to be exceedingly influential in relation to innovation acceptance or rejection within a population. The diffusion of innovations theory clarified how innovations, such as technology, diffuse through populations (Rogers, 1962). Rogers's (2003) theory includes evident adoption categories, ultimately leading to the acceptance or rejection of innovation. Adoption categories begin with recognizing a need for change and conclude with the acceptance or rejection of innovation (Rogers, 2003). A trial typically follows the determination of the means of innovation adoption, enabling choice confirmation (Rogers, 2003). A visual representation of the adoption categories, as depicted in Rogers's (1962) diffusion of innovations theory, appears in Figure 1.

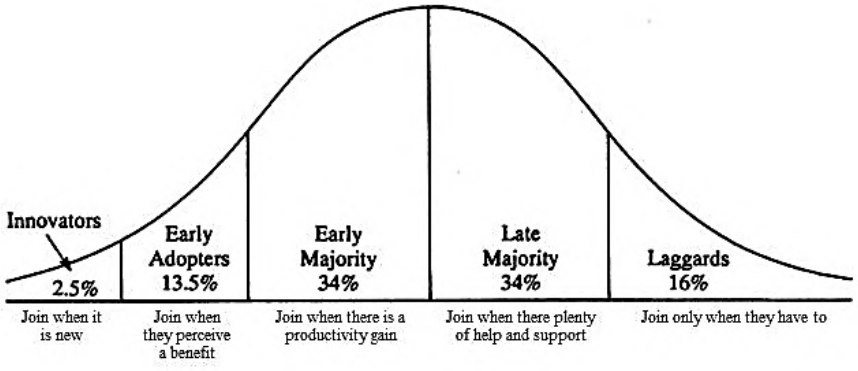

Figure 1. Diffusion of Innovations Theory: Categories of Adoption

Note. Diffusion of Innovations Theory: Categories of Adoption. From Diffusion of Innovations (1st ed., p. 22), by E. M. Rogers, 1962, Free Press. Copyright 1962 by Free Press. Reprinted with permission

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Rogers (1962) included five construct phases within the diffusion of innovations theory (see Figure 2), beginning with the acquisition of knowledge. Knowledge allows individuals to become informed regarding innovation, potentially leading to later acceptance and adoption (Rogers, 2003). The next phase, persuasion, enables individuals to begin determining their positioning for or against innovations (Rogers, 1962). Foundational information emerges from completing Rogers's (2003) previous phase of knowledge, allowing for perception development. Influence on perception acceptance may occur during the persuasion phase, when subjects may become aware of influence and seek guidance from others, even comparing tentative perceptions (Rogers, 2003).

Figure 2. Construct Phases in the Diffusion of Innovations Process

Note. There are five construct phases in the diffusion of innovations process. From Diffusion of Innovations (1st ed., p. 163), by E. M. Rogers, 1962, Free Press. Copyright 1962 by Free Press. Reprinted with permission

The following research question helped support this interpretive phenomenological qualitative study: How do selected educators in the Southeastern United States perceive their knowledge for delivering instruction through one-to-one technology in the classroom?

Presentation and Analysis of Findings

In this section, we outline the presentation and analysis of all study themes, which served to answer the research questions. We evaluated participants' interview responses to interpret their experiences with one-to-one technology and categorized them into common themes. Subsequently, we analyzed the findings in alignment with the existing literature and Rogers's (1962) diffusion of innovations theory to confirm or disconfirm. No unfamiliar, opposing, or unreliable data were revealed.

Generational Gaps and Teaching Through Traditional Methods. The concept of classroom organization, including content delivery followed by in-class assignments and outside homework, is a decades-long practice in education (Abedi et al., 2019). Instructional delivery through technology-based methods is becoming increasingly widespread due to their flexibility and the impact on district budgets (El Mhouti et al., 2016; Li-Tze & Hung, 2015). However, Çelik et al. (2017) found that the use of new technology may also lead to a lack of motivation to complete classroom tasks and technology distraction. Study participants expressed a preference for delivering classroom instruction in person or through paper-and-pencil methods, rather than relying on one-to-one technology. Participants emphasized the importance of establishing rapport with students and fostering educational relationships, which can be enhanced by connecting with them. Educator 3 described how a positive educator-student relationship was crucial to student performance, stating:

> It is how to do things together. I feel like the technology is taking away from that, and I do not want to be that teacher who says, "Here is a tablet; learn from that," when I could be teaching them something.

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These data findings confirmed that some educators and students still prefer face-to-face instruction (Dang et al., 2016). Ge et al. (2021) noted that while acceptance and motivation to use educational technology may be prevalent, caution should be exercised when using one-to-one technology in primary grades. The previous statement aligns with the importance of considering the educator's teaching philosophies when setting expectations for new technology usage within the classroom (Oigara & Ferguson, 2017). The data results agreed that classroom instruction, delivered by an in-person educator, should take priority over the requirement of technology usage (Munzur, 2017). Additionally, negative perceptions of technology integration may stem from inadequate training in devices or programs (Saxena, 2017).

Study participants noted that new technology alone should not be sufficient to reimagine classroom instruction (Varier et al., 2017). In agreement with the study participants, Lorenzo (2017) also discussed that students who primarily completed face-to-face instruction ultimately scored better on summative assessments. Ultimately, an educator has a significant influence on student progress (Opper, 2019). Ultimately, an ideal classroom instruction organization may include an effective and efficient combination of in-person and one-to-one technology (Karthik et al., 2019). Actual one-to-one technology impacts are also undetermined (Hull & Duch, 2019). There is still a need to research further the benefits and hindrances of nontraditional, face-to-face, paper-pencil classroom instruction (D. K. Smith, 2021).

Educators and Educational Technology

A large amount of existing technology is available to educators (Scheuerell, 2015). Free primary and secondary resources allow educators and students to easily access them using school or home devices (Scheuerell, 2015). Mitchell et al. (2016) detailed that educators with three or fewer years of experience were most likely to demonstrate willingness to integrate classroom technology. Haydn et al. (2014) highlighted genuine efforts to utilize technology in transforming classrooms into student-centered learning environments.

Although educators may be familiar with technology, their ability to adequately implement and integrate it does not naturally follow (Rabikova, 2023; Mueller et al., 2008). Ertmer et al. (2012) supported primary factors in new technology acceptance, including existing educator attitudes, perceptions, and low knowledge levels. Bingimlas (2009) indicated that educators desire to integrate technology but struggle with obstacles such as a lack of confidence, competence, and access. Gu et al. (2013) sorted educator barriers into several main groupings: "outcome expectancy, task-technology fit, social influence, and personal factors" (p. 393). Personal factors influencing the implementation of classroom technology use include overall willingness to accept new technology, general confidence, and the necessary investment of time for beginning implementation (Gu et al., 2013). Ertmer (1999) found that the reasons educators struggle with integrating new technology can be both extrinsic and intrinsic.

Bonds-Raacke and Raacke (2008) observed that students are traditionally more accepting of implementing new classroom technology. Hassan and Geys (2016) suggested that reasons for students' acceptance include existing technology knowledge and a desire to be more involved in learning. Sommerich et al. (2007) found that students who were provided with handheld devices for classroom use felt 67% greater ownership toward learning and had

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a 42% stronger connection among peers, educators, and administrators. Bonds-Raacke and Raacke (2008) also found that handheld educational technology led to students' perceptions of feeling more involved and improved abilities for stronger communication. Alvarez et al. (2011) found tablets provided higher student confidence levels, leading to free expression of ideas and a willingness to take risks.

Varier et al. (2017) conducted a study focusing on educators' and students' use of various technological devices, such as phones, and the effectiveness of creating a learner-focused educational atmosphere and developing 21st-century skills. Varier et al. used their study to lay the foundational groundwork before a district decided to adopt one-to-one devices for use through daily instruction. Varier et al. noted that student engagement increased as students gained ownership over in-class responsibilities and perceived assignments as applicable compared to the real world.

Educational Technology and Student Academic Achievement

Research regarding one-to-one technological devices in the classroom has been relatively limited and varies regionally (Howley et al., 2011). Howley et al. (2011) researched technology acceptance within rural settings and discovered that variations in acceptance included positive adjustments to technology, reduced resistance to change, and a more relaxed educational environment. Additional research is necessary to determine student outcomes in one-to-one classrooms, particularly in relation to the use of technology and measurement of student mastery (Cho & Littenberg-Tobias, 2016). Union et al. (2015) compiled research comparing e-readers to the Georgia State Test, collecting data from various third-grade classrooms in a single Georgia school district. Additional research in other geographic regions is necessary to expand the research on one-to-one technology usage in education (Howley et al., 2011).

Hassan and Geys (2016) identified a need to determine appropriate instructional methods using new technology. Hassan and Geys' research findings do not include a protocol for introducing technology into the curriculum (Hassan & Geys, 2016). Additional research is also necessary to examine perceptions of technology among educators with more than 20 years of teaching experience, the group least likely to willingly integrate technology (Mitchell et al., 2016). In contrast, Young (2017) concluded that although student motivation toward technology use is typically examined through research, a measurement of basic technology skills gained through increased use of one-to-one technology devices is still lacking.

One-to-one classrooms require high technology interaction at school and home (Cho & Littenberg-Tobias, 2016). Research is lacking regarding the frequency of user access to classroom handheld devices (Hassan & Geys, 2016). The availability of technology at school may not match that at home, although usage in both settings may be necessary (Cho & Littenberg-Tobias, 2016). There are few studies on the impact of technological devices while delivering instructional interventions (Islam & Gronlund, 2016).

Instruments to qualitatively measure current educator perceptions of technology are limited (Cho & Littenberg-Tobias, 2016). Skill and confidence levels show high acknowledgment through researching tools, but there remains a lack of evidence of educator perception for technology integration (Schmidt et al., 2009). Bebell and Kay (2010) determined low student engagement levels and quality of work using technology. Mathison (2012)

developed a character education technology instrument; however, the measure was student-based, leaving out educator perspectives.

Educational Technology and Classroom Instruction

At the pace at which technology changes, it is challenging for researchers to keep pace with recent developments and current trends in technology use in education (Mitchell et al., 2016). Components of a single study have the potential to open additional avenues for research and data collection (Howley et al., 2011). In 2016, the district in which this research study was conducted implemented a new one-to-one student-to-technological device ratio into policy, with all students issued their handheld electronic tablet (Florida Department of Education, 2014). Since policy inception, delivery of daily instruction has occurred primarily through this device (Florida Department of Education, 2014). Research must determine whether one-to-one classrooms elicit negative or positive perceptions among educators (Mitchell et al., 2016). People tend to form perceptions of new ideas based on their personal attitudes and prior experiences (Cho & Littenberg-Tobias, 2016). Established personal beliefs may influence motivation to use new technology (Leonardi, 2009; Zhao & Frank, 2003).

The foundation for RQ1 was the knowledge construct of Rogers's (1962) diffusion of innovations theory. Knowledge allows initial exposure to innovations, potentially providing the foundation for acceptance or rejection (Rogers, 2003). Additionally, the knowledge construct includes delivering up-to-date information involving innovation usage and clarifying misconceptions (Rogers, 1962). Rogers (2003) expressed that the more knowledge delivered at the onset of adoption inception, the higher the likelihood of larger acceptance and comfort in usage. The study data revealed two themes: educator confidence and insufficient training. Educational Technology and Educator Confidence. Educator confidence in new technology is crucial, particularly when expectations follow for educators to integrate technology into instruction both effectively and efficiently (Lawrence et al., 2018). Educators are tasked with simultaneously learning newly adopted classroom technology and delivering instruction using technology while exhibiting their classroom knowledge (Lawrence et al., 2018). Study participants relayed a positive level of self-confidence in using classroom technology. However, this confidence level was only exhibited once the classroom technology had become routine and educators felt comfortable using it in front of the students. Educators continued to share that once new technology was expected to be implemented, confidence was meaningfully diminished. One participant expressed a low level of confidence if something new was expected, claiming:

> I can do basic stuff. For example, I have an InterWrite board. I can do all the basics, but I'm limited in what else I can do... I am not naturally computer savvy. I understand the foundation well, but to go beyond that, I probably lack the necessary training to succeed.

These findings are confirmed by research that a lack of educator confidence with new technology hinders motivation for technology-based learning (Whiteside et al., 2020). Additionally, students will likely perform better when an educator feels confident using the provided instructional technology (Sangkawetai et al., 2018). Participant responses agreed with the literature that the successful use of classroom technology depends on the educator's ability to use it with confidence (Alenezi, 2017). J. A. Evans (2020) noted that educator confidence in

using instructional technology increased by 10% during the COVID-19 pandemic, mainly due to the necessity of learning technological devices quickly to provide instruction at a distance. Overall, participant statements aligned with the literature, confirming that educators do not typically feel comfortable or confident using newly adopted technology for classroom instruction (Borthwick & Hansen, 2017).

Insufficient Training in Educational Technology. In 2017, the U.S. Department of Education highlighted the importance of sufficient educator technology training for classroom success and effective technology implementation. Exemplary classroom instruction is partially due to adequate training on adopted materials and programs (Alenezi, 2017; Çoruk & Tutkun, 2018). Understanding educators' perspectives and possible hesitations before introducing new technology is crucial for fostering their willingness to learn new devices and programs (Cho & Littenberg-Tobias, 2016; Nikolopoulou & Gialamas, 2016; Saxena, 2017).

Without educators' willingness to effectively implement newly adopted devices, students perceive using one-to-one devices in the classroom as boring (Çoruk & Tutkun, 2018). Study participants reported that training was not provided at a sufficient level before the expectation of classroom implementation arose. While some educators stated that training had been provided, it was not provided on the specific programs or at a level that gave educators the confidence to integrate the technology into the classroom. Educator 3 stated that insufficient training had been delivered and additional areas within a specified program needed more professional development. Educator 3 relayed,

> We were not given any training beforehand. We did not receive that much support. It was almost as if they said, "Here are your devices, this is how we will do it." There was not a ton of training. At first, we had touchscreen tablets; now we have Chromebooks, and we have to teach students to use the mouse pad. It has been tough, but we were not given as much extra education as we should have.

These data findings align with the literature, which suggests that educators often receive insufficient crucial training and follow-up support; however, participants were expected to implement one-to-one devices within classrooms immediately (Whiteside et al., 2020). To be effective, educators should receive the necessary training on technology-based instructional devices so that effective classroom instruction can occur (Lorenzo, 2017). It is also important to note that educators come from varying backgrounds and have diverse experiences with technology (Saxena, 2017). Therefore, professional development on device and program usage must meet the educators' current knowledge level to succeed in classroom transfer (Saxena, 2017).

Study participants' responses agreed with the literature that only receiving training in one-to-one devices or programs does not guarantee effective classroom implementation (Saxena, 2017). Participant findings aligned with the literature, which states that adequate training on devices and programs builds educators' knowledge and confidence in implementing classroom technology correctly (Sangkawetai et al., 2018). Ultimately, specific training and technical support provided on one-to-one devices and programs used within those devices lead to greater comfort for educators expected to implement the technology within their classrooms (Cutts, 2019). According to Sadaf and Johnson (2017), one-to-one instruction may benefit student learning outcomes if adequate training is provided.

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The need for Professional Development in Educational Technology. School districts are shifting from face-to-face instruction to one-to-one technology to create 21st-century learners (Varier et al., 2017). Successful new technology implementation and comfort are based mainly on educator comfort with devices and program comfort (Saxena, 2017). Study participants expressed that training in specific programs and device usage would encourage educators to use one-to-one instructional devices more frequently. Participants elaborated on how proficient training would lead to greater motivation to incorporate one-to-one technology in more content areas and seek further student learning opportunities. One participant shared that they were told:

> Here is your device; play with it until you can figure out what you can do." As a visual learner, I must know what is acceptable and unacceptable. If I had more confidence, I could relay it to my children. I see the good in it, but I am inadequate, so I do not feel I can benefit my children by wasting time.

These data findings confirmed that when educators have appropriate training and technology-based confidence, a larger spread influence may be possible, leading to other educators better accepting newly adopted technology (Lawrence et al., 2018). Study participants requested additional training to implement the newly adopted programs best. Teachers do not want to know how to troubleshoot one-to-one technology issues as they arise (Alenezi, 2017). Moreover, educators are seeking out district leaders to aid in one-to-one instructional implementation assistance (Alenezi, 2017; Masullo, 2017). Ultimately, maintaining educator requests for additional training, and the changing pace of technology changes should be considered with both pattern and intentionality (Silber-Varod et al., 2019).

Educational Technology and Differentiated Instruction. Classroom technology offers an opportunity to advance differentiated instruction (Lorenzo, 2017). Lorenzo (2017) also determined that students must match higher-order thinking skills, which they may obtain through instructional technology, to align with 21st-century expectations. Study participants expressed classroom adaptations occurring as a result of one-to-one technology usage. As a result of one-to-one technology, classroom instructional time could be more efficiently used to remediate students' needs or enrich students' strengths through differentiation. Participants also shared that one-to-one technology provided time for educators to monitor students' progress and examine if intervention practices proved effective. Educator 2 described how one-to-one technology was effective at monitoring student progress.

These data findings confirmed that student progress stalls when educators are not proficient in technology usage and implementation expectations (Saxena, 2017). Unfortunately, educators who feel unprepared to implement classroom technology may also experience increased pressure to prioritize evidence of student growth over building confidence to use one-to-one technology more effectively (J. A. Evans, 2020). Study participants confirmed the literature that one-to-one technology is effective at meeting higher-order differentiation needs (Cristia et al., 2017). Additionally, while some educators may have hesitant attitudes toward adopting integration, effective differentiation with one-to-one technology can increase assessment scores (Vu et al., 2019). Although the literature has stated that grade-level expectations may be measured through technology-based resources, there are no valid or reliable assessments to measure technology-based skills (Digital Promise, 2018). Ultimately, study

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participants agreed with the literature that student progress should be measured in technology-based skills and progress monitoring of state-based standards (Digital Promise, 2018).

Educational Technology and Student Independence. Classroom environments have shifted from whole-group to independent, technology-driven instruction (Islam & Gronlund, 2016). Student independence is critical for accomplishing more technology-based instructional tasks (Duret et al., 2018; El Mhouti et al., 2016; Hadiyanto, 2019). Students may be motivated to learn independently through one-to-one technology (Tondeur et al., 2016). Study participants explained that classroom adaptations occur due to one-to-one technology usage. In addition to effective student differentiation, efficient student independence was expressed as an educator adaptation. Data participants shared how one-to-one technology provides opportunities for students to become more independent in guiding their instructional choices, allowing the educator to meet all students' needs better. Educator 1 voiced how the frequency of usage and the increasing number of devices allow students to become more independent and accustomed to one-to-one technology as an established classroom routine. Educator 1 expressed,

These data findings confirmed the literature that students have embraced a certain level of ownership only offered through one-to-one technology (Lorenzo, 2017; Munzur, 2017). Study participants agreed with the literature that students can better self-create learning experiences through one-to-one technology (Hadiyanto et al., 2021). However, one-to-one technology should not be implemented entirely, as the absence of peer collaboration could lead to feelings of isolation (Duret et al., 2018; El Mhouti et al., 2016). Meaningful technology learning tasks, providing opportunities for group ownership, and including clear procedures, should aid in calming student hesitation to organize as a group (Magen-Nagar & Shonfeld, 2018). Ultimately, study participants agreed with the literature that opportunities for instructional peer conversation and ownership through independent one-to-one tasks should be methodically combined when available (Hadiyanto, 2019).

Educational Technology and the Fourth Industrial Revolution.

Scholars identify four types of industrial revolutions, each associated with new technologies. According to Akor,

> The first industrial revolution utilized water and steam power for mechanization and production; the second used electricity for mass production; the third made use of electronics, information, and communication technology for automated production; and now, the fourth industrial revolution (4IR), which is building on the digital revolution from the third industrial revolution (2018, p. 787).

What is unique about the Fourth Industrial Revolution is the speed of mass production and the near fusion of the digital and the biological mediated through technology. The growth of automation and artificial intelligence is part of the results of the technologies of the Fourth Industrial Revolution (Steigler, 2015; Akor, 2018). Educators and students have been able to use the technologies associated with their respective Industrial Revolutions to maximise teaching and learning opportunities. For Bianchini, the Fourth Industrial Revolution ushers in a new paradigm shift that will significantly affect the nature of teaching and learning (Bianchini, 2020).

Schwab (2016) identifies the beginning of the Fourth Industrial Revolution with the rapid and radical transformation of information due to technology, especially the internet. Under conditions of the Fourth Industrial

Revolution, the role of the teacher, the textbook, and the student will be transformed (Haziazi, 2021). A general characteristic of the Fourth Industrial Revolution will be the dependence on machine intelligence in all fields of human interaction, including education. As a result of new technologies and the internet, "education systems must recognize the importance of teaching based on digitally assisted methods" (Haziazi, 2021, p. 10).

The growing Role of Artificial Intelligence in Education

The emergence of artificial intelligence (AI) is relatively new, but it is a natural progression of the role of technology in education (Schwab, 2016). In the USA, directives on using and implementing AI in the classroom are relatively new compared to other countries (Prlja et al., 2021; Camputaro, 2024). Camputaro (2024) and Schwab (2016) identify four industrial revolutions, each associated with different technologies. For Schwab, AI is part of the technology that ushers in and consolidates the Fourth Industrial Revolution. However, AI is built on the technologies of previous industrial revolutions, culminating in the International Society of Artificial Intelligence in Education (IAIED) creation in 1993 (Camputaro, 2024). As a result of the technologies of the Fourth Industrial Revolution, "the whole world of education must, and will be transformed by AI tools" (Rabikova, 2023, p. 314).

> Like other forms of educational technology, teachers have been relatively slow to embrace AI.

According to Cukurova:

> The slow adoption of AIED systems in real-world settings might, in part, be attributable to the frequent neglect of a range of other factors associated with complex educational systems. These include but are not limited to understanding and deliberately considering the learners' and the teachers' preferences (2023, p. 152).

Rabikova points out that educators must know the different types of AI tools and their advantages (Rabikova, 2023). Research indicates that about 38% of students in the USA use AI, while globally, the percentage is slightly higher (Camputaro, 2024). When it comes to teachers, on the other hand, only twenty-five percent are familiar with, or use AI (Haziazi, 2021). Under the Fourth Industrial Revolution, conditions indicate that traditional teaching methods are becoming outdated as younger generations use more technologically informed methods and AI-related technologies. With the installation of the Fourth Industrial Revolution and the increased role of AI in education, teachers will no longer be the sole source of information in the classroom. According to Haziazi, "emerging technologies will make learning in the future adaptive and more individualized because of the use of smart learning technologies" (2021, p. 12).

As part of the Fourth Industrial Revolution, AI will have a singularly transformative impact on education for teachers and students (Pelaez et al., 2022). Stosic contends that AI "aids in personalized learning, student support, enhancing the efficiency of the teaching process, increasing educational accessibility, and monitoring student progress" (2023, p. 60). In other words, AI can teach students and teachers because of the data it can rapidly access on the internet. However, educators need to know that there are different types of AIs, each designed for a specific purpose to enhance the teaching process while personalizing learning. While we are in the Fourth Industrial

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Revolution, AI remains an integral educational tool that teachers and students resist to their disadvantage, especially with the exponential growth of human-centered and education-oriented AI (Kashyap et al., 2024).

Implications

All educational technology has implications for pedagogy and impacts teachers and students. Since society creates technology, teachers and students will have to use technology. The emergence of artificial intelligence will require teachers and students to engage with it. There are regional and national differences regarding the depth with which countries and educational systems are utilizing artificial intelligence. Educators and students, particularly in the USA, will have to adapt to artificial intelligence trends and other educational technologies ushered in by the Fourth Industrial Revolution. For effective learning to occur, educators must be equipped to utilize the technologies available to them. New teaching methods will have to be devised to adjust to the realities of the Fourth Industrial Revolution to help students learn. Educators must integrate the technical and pedagogical features of Fourth Industrial Revolution technologies (Siraj, 2009). Digital literacy is a hallmark of Fourth Industrial Revolution education (Dewi, 2019).

Limitations

Our study focused primarily on forms of educational technology from the Third Industrial Revolution. However, it did not delve into Fourth Industrial Revolution educational technologies, including artificial intelligence, which has proliferated the human condition under the Fourth Industrial Revolution. While we acknowledged the reality of educational technologies of the Fourth Industrial Revolution, our study did examine the different types of AI and their advantages and disadvantages, as well as educators' knowledge of using such technologies.

Conclusion

In conclusion, this paper provides insights into the challenges and opportunities teachers face in using educational technology. Using Rogers' Diffusions of Innovations theory, we highlighted how technology has become part of the educational landscape. Interview data indicate that when given opportunities to utilize educational technology, educators adjust and learn to use technology as a pedagogical tool. We also pointed out how students are often more knowledgeable about technology than teachers. While teachers are sometimes hesitant to use technology, educational administrators can play an important role by providing resources and professional development opportunities for teachers to gain more confidence in using technology. As new technologies emerge, some educators resist adopting and using them, while others utilize them to enhance their skills and improve teaching and student learning. We concluded by arguing that the technological changes of the Fourth Industrial Revolution, including AI, have ushered in new opportunities that educators should engage with. Research indicates that teachers eventually become adept at using new educational technologies when granted sufficient training, which should hold for AI. At the same time, the rapid pace of technological changes characteristic of the Fourth Industrial Revolution leaves teachers and students with little time to adjust to new realities. The Fourth Industrial Revolution and AI will soon make traditional teaching methods obsolete. Although most countries and educational systems are in the early phase of learning about AI, Rogers' Diffusion of Innovations and Categories of Adoption theoretical framework offers hope that educators will be open to utilizing AI to maximize student learning. Our study showed that teacher attitudes toward new educational technologies grew when educators saw their ability and confidence

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grow about the usefulness of the technology in question. With proper scaffolded training and implementation guides, there is evidence that teachers are more than capable of embracing and utilizing educational technologies, including AI. For this to be effectively done, teacher education programs must play a leading role, while professional development opportunities should be made available to seasoned teachers. Educators have always been encouraged to use technology to enhance their teaching to optimize student learning. AI significantly changes the learning environment and the relationship between teachers and students.

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