Tech-Driven Teachers: Embracing Digital Innovations to Shape the Future of Preservice Education and Instructional Design

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ABSTRACT

Embracing the 5.0 era and its radical changes to the teaching landscape, digital innovations in pre-service teacher education have garnered significant attention, as instructional design competencies are critical for today's educators. Despite the growing interest and promising advancements in technology, integrating these innovations into educational practices remains a complex challenge. This research paper explores how learning technologies, such as adaptive learning systems, virtual reality (VR) environments, and collaborative online platforms, can be adopted to enhance teacher training and instructional strategies, examining current applications, potential benefits, and the hurdles faced by teachers and institutions. This research employs a qualitative approach, drawing on case studies and a review of existing literature to provide a comprehensive analysis of digital integration in pre-service teacher education and instructional design. By synthesizing recent research and theoretical perspectives, this paper aims to offer actionable insights for educators and policymakers seeking to optimize teaching and learning outcomes in the digital era.

Keywords: Digital innovations, pre-service teacher education, instructional design, learning technologies

1). INTRODUCTION

In today's rapidly evolving world, the 5.0 era concept marks a transformative shift in how we approach and integrate technology into various aspects of our lives. This new era represents a fusion of advanced technologies, including artificial intelligence, the Internet of Things (IoT), and big data, with human-centric values and goals. As we stand on the brink of this new era, its implications for education are both profound and promising. We can refer to this phenomenon as Education 5.0.

Education 5.0 is not merely about adopting new tools, such as adaptive learning systems, virtual reality (VR) environments, and collaborative online platforms; it signifies a fundamental change in how we conceive learning environments, tailor educational experiences, and prepare students for a future that is increasingly shaped by technology. For instance, schools are now utilizing VR to provide

immersive learning experiences, allowing students to 'visit' historical sites or virtual music gallery, and conduct scientific experiments virtually, as demonstrated by 'SD Cikal Cilandak', 'SMA Negeri 4 Denpasar, 'SMP Muhammadiyah 2 Sidoarjo', etc. Some other schools also have special curricula that engage students in creating digital innovations.

Digital innovations are at the forefront of Education 5.0 as they revolutionize traditional teaching methods and enhance the learning process. They will not only provide new tools but also emphasize personalized learning experiences that cater to the individual needs and learning styles of students. Adaptive learning systems can assess a student's progress and adjust content accordingly, fostering better outcomes. Additionally, digital innovations enable teachers to collect and analyze data on student performance and engagement. This data can inform teaching strategies and curriculum design, leading to continuous improvement in educational outcomes.

It would be beneficial if the integration of digital innovations into education started earlier. As technology continues to evolve, starting digital integration earlier can create a foundation that supports lifelong learning and equips students with the skills they need to thrive in a rapidly changing world. By leveraging these advancements, this paradigm shift offers an opportunity to rethink traditional educational practices and embrace innovative approaches that align with the demands of a dynamic and interconnected world. Failing to address the lack of technology integration in the learning environment contributes to the digital divide, hindering the quality of teaching and learning at higher education levels.

This paper aims to analyze the role and importance of digital innovations in Education 5.0 and their impact on the learning and teaching process. It provides a comprehensive understanding of how technology can be integrated into education. This topic is highly relevant for pre-service teacher education as it offers a deep understanding of the evolving educational technologies. Future teachers need to master digital innovations to design engaging and effective learning experiences and to leverage technological tools to support their teaching practices. By understanding technology-based instructional design, they can create curricula that are responsive to students' needs and facilitate student-centered learning. Therefore, this topic significantly contributes to equipping future teachers with the skills and knowledge necessary to enhance the quality of education in the digital age.

2). METHODS

This research is a qualitative research utilizing a literature review method. This method gathers information or data from relevant books, journals, or articles related to the topic being studied. The goal is to acquire information or data about a comprehensive analysis of digital integration in pre-service teacher education and instructional design.

3). RESULTS AND DISCUSSION

1. Adaptive Learning Systems in Pre-Service Teacher Education

The use of educational technology typically appears to have a moderately beneficial impact on learning and performance. However, research also highlights the challenges in customizing technology to meet the unique needs of each learner (Rosen and Salomon, 2007; Tamim et al., 2011; Cheung and Slavin, 2012; Cheung and Slavin, 2013). An emerging and growing trend in this field is the adaptive learning system, which is revolutionizing education, particularly in pre-service teacher education.

Adaptive learning systems offer inherent opportunities to personalize curricula and learning experiences for each individual learner and to support teacher-facilitated learning. The Artificial Intelligence (AI) community has long explored how technology could mimic professional thinking (Abbott, 1988), and the potential of computers as digital tutors has been recognized and examined for many years. Using artificial intelligence (AI) technologies to simulate teachers' knowledge and experience to provide individual students with personalized supports or guidance has been recognized as a potential solution (Pai et al., 2020; Xiao & Yi, 2020). This system enables the customization of educational content and curriculum to match individual learner skill levels and personalizes their learning experiences through the use of algorithms, artificial intelligence, and machine learning.

However, emerging algorithm-based adaptive learning systems present different advantages and limitations compared to traditional educational technologies. An ideal adaptive learning system would theoretically keep learners in a constant state of flow, which is achieved when their skills align with the activity's difficulty—striking a balance between challenge and boredom (Csikszentmihalyi, 2009; Gallego-Durán et al., 2018). When the difficulty level surpasses learners' skills, it can cause anxiety, whereas activities that only involve what learners already know can lead to boredom. Therefore, keeping learners in a state of flow is linked to enhanced motivation.

This system is well-suited for pre-service teacher education because the abilities of pre-service teachers can vary significantly. It is crucial for them to first experience being the learner within the adaptive learning system, because the system can customize training and support for pre-service teachers based on their progress, strengths, and areas for improvement. This hands-on experience will provide a thorough understanding of how to effectively implement the system in classroom management when they eventually work with students. Research indicates a significant link between a teacher's digital competence and their effectiveness in classroom management (Moltudal et al., 2019). When pre-service teachers are well-prepared, there will be successful integration of technology into education in ways that benefit students. For example, Pai et al. (2020) developed an intelligent tutoring system, as a specialized subset of adaptive learning systems, designed to assist fifth-grade students in mastering multiplication and division. Their research indicated that this system not only enhanced the students' performance in mathematics but also boosted their motivation to learn.

However, employing digital tools and software like adaptive learning technologies for educational purposes generates substantial amounts of data related to learner activities, academic progress, competence levels, and more. The utilization of this data for educational interventions and to support learning is commonly referred to as "learning analytics" (Lang et al., 2017). Interventions driven by learning analytics have the potential to either support existing educational practices or challenge and transform them (Knight and Buckingham Shum, 2017).

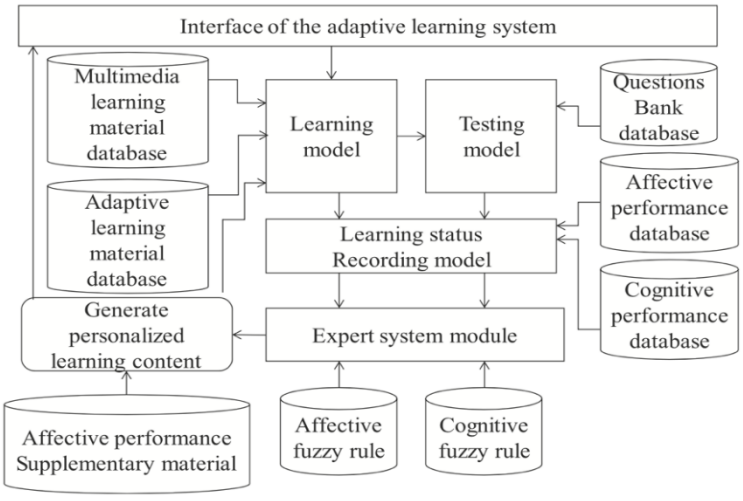

Fig. 2. The interface of adaptive learning system (Hwang et al., 2020)

2. Revolutionizing Instructional Design through Virtual Reality

In the past decade, Virtual Reality (VR) has seen as a promising technology to enhance learning outcomes. This advancement is particularly significant in pre-service teacher education, where VR can offer immersive and interactive training experiences. For pre-service teachers, integrating VR into their education provides opportunities to practice and refine their teaching skills in simulated classroom environments. In the realm of VR, it must account for its development toward a fully immersive synthetic spatial reality, where users can engage with highly realistic simulations of virtual environments. This advancement incorporates sophisticated technologies, including motion tracking systems, brain-computer interfaces, and haptic feedback (Chen, 2015; Radianti et al., 2020).

Over the years, VR has broadened and solidified its presence across various fields. It has become a widely utilized teaching tool that pre-service teachers can later employ in their own classrooms once they complete their education. Examples include: a) Health Sciences, where it is used for depicting organs or developing manual skills, such as in chemistry labs, anatomy atlases, and dental morphology; b) Engineering, with applications like building design and planning, virtual engineering labs, and simulation of engineering techniques; and c) Humanities, where it supports second language learning in context and virtual tours of historical sites (Hess and Greer, 2016).

Enabling this potential in a widespread manner, it's crucial to develop instructional models for VR that align with established principles of instructional design and educational technology standards, ensuring that future educators are well-prepared to implement these innovative tools in their own classrooms. According to the Association for Educational Communications & Technology, instructional design for distance learning should follow ten standards: Purpose, Assumptions, Sequence, Activities, Resources, Application, Assessment, Reflection, Independent Learning, and Evaluation. Purpose involves aligning course goals and objectives with its structure and student interaction. Assumptions address students' prior knowledge and their ability to use the course's technology and tools. Sequence refers to the learning pathway and its impact on the efficient acquisition of knowledge. Activities involve adapting the content and learning objectives. Resources ensure technological accessibility. Application provides opportunities for students to apply new knowledge. Assessment includes both continuous and formative feedback. Reflection deepens the learning experience. Independent Learning incorporates feedback, review, and reflection

opportunities. Finally, Evaluation focuses on goal orientation, assessing new knowledge and skills, and includes self-assessment by both instructors and students (Piña, 2017; Piña, 2018).

A well-designed instructional model for VR should integrate instructional design standards as outlined by the Association for Educational Communications & Technology. This ensures that the VR experience is crafted with consideration of learning objectives, user abilities, content sequence, and other crucial factors essential for effective education in a VR environment. Four instructional design models for immersive VR were identified from the survey process: (1) XR ABC Framework (Shippee and Lubinsky, 2021); (2) iVR Learning (M-iVR-L) Framework (Mulders, Buchner, & Kerres, 2022) ; (3) TESLA Instructional Design Model (Fragkaki, 2019); (4) Castronovo et al. Design Model (Castronovo et al., 2019).

The XR ABC Framework which includes three steps—Absorb, Blend, and Create—has limited detail in its description. It only briefly touches on the standard Assumptions in the Absorb stage by referring to moments of recollection to consider prior learning and students' existing knowledge. The Blend stage addresses the Activities and Resources standards by introducing various tools to enhance experiences. Finally, the Create stage focuses on allowing students to develop their own resources, but does not provide extensive guidance on these aspects.

The iVR Learning (M-iVR-L) Framework offers six recommendations grounded in the Cognitive Theory of Multimedia Learning to enhance the learning process using immersive VR. One of the key recommendations, "Learning first, immersion second," emphasizes the need to prioritize the learning process over the immersive experience by managing the use of VR resources effectively. Another important aspect is the recommendation to "Segment complex tasks into smaller units," which highlights the value of breaking down tasks to reduce cognitive overload and facilitate better learning management. The recommendation to "Provide learning relevant interactions" stresses the importance of preparing students with both basic concepts and effective use of interactive tools.

Additionally, the framework emphasizes orientation through the recommendation to "Guide immersive learning," which focuses on assisting students in navigating and managing their learning within the VR environment, where cognitive demands are higher. The recommendation to "Build on existing knowledge" reflects the importance of connecting new learning with students' prior knowledge. Finally, the recommendation to "Provide constructive learning activities" suggests

implementing activities that help build and apply knowledge to new problem-based tasks, both within and outside the VR environment, to enhance learning application.

TESLA Instructional Design Model is a combination of three different instructional design models: ASSURE, TPACK, and Kirkpatrick. The ASSURE model emphasizes setting goals and objectives through Analyze Learners and State Standards and Objectives; and focuses on planning how the resources will be used to contribute to the acquisition of the objectives in which there is a focus on Selecting Strategies, Technology, and Resources. The TPACK model is incorporated, bringing in elements of critical reflection related to the reflection standard, and emphasizing the importance of technological knowledge, particularly concerning specific methods of thinking and acting, such as those used in VR. Lastly, the evaluation standard involves the "Evaluate and Revise" phase, incorporating Kirkpatrick's evaluation model.

The Castronovo et al. Design Model is introduced as a way to adapt the ADDIE (Analysis, Design, Development, Implementation, Evaluation) Instructional Design model for use in Immersive Virtual Reality teaching. In this specific case, only three of the five ADDIE steps were utilized. This application of the model demonstrates the presence of purpose through analyzing students and defining objectives; resources through designing and organizing the learning materials; and application during the development phase when implementing the activities.

Of the four models, two groups stand out: one group includes those that offer suggestions specifically for the VR context and were developed for it; the other group consists of models applied to the VR context but originally developed in a more general instructional design setting. The first group includes the XR ABC Framework and the iVR Learning (M-iVR-L) Framework, which provide recommendations related to VR usage, such as task segmentation, managing immersion time, and offering pre-instruction contact with the tool. The second group consists of the TESLA model and the model by Castronovo et al. These more general models emphasize the importance of setting objectives for the target audience, considering evaluation elements, and defining the use of resources and purposes, among other factors. (Soklaridis, Chowdhury, M., Turco, M. G., Tremblay, M., & Mazma, 2024)

The iVR Learning Framework (M-iVR-L) stands out as the most comprehensive support for designing Virtual Reality classes. However, it does not fully align with all the standards set by the

Association for Educational Communications & Technology (AECT) (Piña, 2018; Radianti et al., 2020). It does present relevant contextual elements that allow for reflection on what needs to be considered when preparing an immersive VR session, such as the need for task segmentation due to the increased load from using the tool. Therefore, there is a need to conduct a future research to develop instructional models for VR that might consider building on the M-iVR-L framework to address all AECT standards.

3. Innovations in Collaborative Online Platforms for Professional Development

In 2024, collaborative online platforms for professional development have reached new heights, leveraging advanced technology to create more engaging and personalized learning experiences. These innovations are reshaping how professionals acquire skills and collaborate, making development more accessible and tailored to individual needs. By integrating cutting-edge tools and techniques, these platforms are enhancing the effectiveness and flexibility of professional growth, ensuring that learners are better equipped to navigate the evolving demands of their fields.

There are three categories to describe types of adaptation to professional development innovations: (1) creation of new online resources; (2) increased use of existing online platforms/software to deliver professional development; (3) use of simulation for teaching and learning (Soklaridis et al., 2024)

3.1. The Creation of New Online Resources

The development of resource and best practice guides aims to effectively adapt and assess professional development for virtual platforms, addressing both format and content. The shift from in-person to synchronous videoconferencing formats, driven by the pandemic, is a key factor in this transition. Kohnke and Moorhouse (2020) note that synchronous online teaching—defined as real-time, one-hour sessions conducted via video conferencing software (VCS)—can enhance learning experiences. Examples of such tools include Zoom, Google Meet, Cisco Webex and Jabber.

Many online resources offer feedback mechanisms, such as quizzes, tests, and interactive exercises, which assist learners in pinpointing areas for improvement and tracking their progress over time (Schwartz, 2020). Additionally, platforms like websites, mobile apps, and interactive tools provide the flexibility to access content at any time, enabling learners to customize their learning experience according to their personal schedules and preferences (Haleem et al., 2022).

Curation of lists of various online resources that could be used for learning in a virtual environment are categorized into several main categories, including (Huda, Janattaka, & Prayoga, 2023): (1) Learning Websites: These websites offer comprehensive learning materials; (2) Online Courses: Many institutions and organizations provide online courses, allowing learners to study at their own pace. These courses often include video lectures, assignments, and assessments. Platforms like Coursera, Udemy, and edX; (3) Podcasts: learning podcasts offer audio content designed to cover a variety of topics and often include transcripts or accompanying materials; (4) Online Communities: These communities provide forums, chat groups, and social networks where learners can interact with fellow learners. Popular online communities include Reddit's, etc; (5) Mobile Apps: It offers a learning tools, including exercises and games; (6) Video Platforms: Video-sharing platforms like YouTube provide a vast array of learning channels. These categories encompass a wide range of online resources that cater to the diverse needs of learners, offering flexibility and convenience in self- paced learning and interactive practice.

3.2. Increased Use of Existing Online Platforms/Software to Deliver Professional Development

The changes brought about by COVID-19 have the potential to build on existing technology use to significantly enhance access to professional development and learning in non-urban areas around the world. Various strategies are available to guide online learning and assessment, such as the Technology Enhanced Learning Accreditation Standards (TELAS), developed by the Australasian Society for Computers in Learning in Tertiary Education. TELAS is an example of a framework designed to evaluate and critique online learning activities, resources, support, and assessment tasks to ensure that learner engagement, alignment between objectives and outcomes, and communication are optimally supportive of learning.

For instance, the flipped classroom model replaces traditional teacher-led content with preparatory individual or group activities before engaging students in interactive face-to-face sessions (Hew & Lo, 2018). Thus, the flipped classroom is seen as an alternative to reliance on face-to-face lectures (Morton & Colbert-Getz, 2017), promoting active and personalized learning (Skiba, 2016).

3.3. Use of Simulation for Teaching and Learning

Online simulations have revolutionized teaching and learning by providing accessible, interactive, and flexible educational experiences. These virtual tools enable students to conduct experiments, explore complex scenarios, and develop practical skills from any location, breaking down geographical and logistical barriers. By offering immersive and risk-free environments, online simulations allow learners to practice and refine their abilities without real-world consequences, while providing immediate feedback and detailed performance analytics. This approach not only enhances engagement and collaboration but also supports continuous professional development, making it an invaluable resource for both academic and career-oriented learning.

4). CONCLUSIONS

The transition into the 5.0 era, characterized by the integration of advanced technologies with human-centric values, represents a significant shift in educational paradigms, encapsulated by the concept of Education 5.0. This evolution underscores the necessity of rethinking educational practices and harnessing digital innovations to enhance both teaching and learning processes.

Education 5.0 goes beyond mere technological adoption; it emphasizes a profound transformation in how learning environments are designed and personalized. The incorporation of technologies such as Artificial Intelligence (AI), Virtual Reality (VR), and adaptive learning systems offers promising avenues for creating more engaging, interactive, and customized educational experiences. These advancements facilitate not only the delivery of content but also the personalization of learning to meet individual needs and preferences.

The literature reviewed highlights the importance of instructional design in this new educational landscape. Effective instructional design, particularly in the context of emerging technologies, is crucial for optimizing educational outcomes. Frameworks such as the XR ABC Framework and the iVR Learning (M-iVR-L) Framework provide valuable insights into designing immersive VR experiences that align with established instructional design principles.

Moreover, the role of collaborative online platforms and simulations in professional development is becoming increasingly prominent. These tools offer flexible, interactive, and accessible learning opportunities that can enhance both skills and knowledge in diverse contexts.

In conclusion, the successful integration of digital innovations into pre-service teacher education is pivotal for preparing future educators to thrive in an evolving technological landscape. Embracing Education 5.0 involves not only adopting new tools but also fundamentally rethinking educational practices to align with the demands of a rapidly changing world. As technology continues to advance, ongoing research and adaptation will be essential for maximizing the potential benefits of these innovations and addressing the challenges they present.

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