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Digital Technologies as a Factor of Transformation of Learning in the University Education

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Abstract: *This article investigates the transformative impact of digital technologies on university education, particularly in light of the accelerated adoption driven by the COVID-19 pandemic. The study aims to explore how these technologies have reshaped teaching and learning processes, focusing on their effectiveness, the challenges they present, and their future potential. The research is grounded in a thorough literature review, coupled with empirical data gathered from interviews with university teachers and students, and enhanced by insights from AI systems. The findings reveal a generally positive reception of digital tools, with significant benefits in enhancing student engagement, providing flexible access to educational resources, and supporting diverse learning modalities. However, the study also identifies key challenges, including the digital divide, the need for continuous faculty training, and the rapid pace of technological change. Additionally, the potential of emerging technologies such as artificial intelligence (AI), virtual reality (VR), and augmented reality (AR) to further personalize and enrich the educational experience is highlighted. The article concludes that while digital technologies offer substantial opportunities for innovation in higher education, their successful integration requires strategic planning, robust policy frameworks, and sustained investment in infrastructure and professional development.*

Keywords: *digital technologies in education; higher education transformation; digital learning; student engagement; artificial intelligence in education; university education.*

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Introduction

The rapid advancement of digital technologies has precipitated a profound transformation in higher education, reshaping the methods and modalities of teaching and learning. As universities worldwide increasingly integrate digital tools and platforms, the traditional classroom paradigm is being redefined, offering new opportunities for enhancing student engagement, accessibility, and learning outcomes (Nalyvaiko et al., 2022). The proliferation of digital technologies such as learning management systems (LMS), massive open online courses (MOOCs), artificial intelligence (AI), and virtual reality (VR) has enabled educators to adopt more flexible, personalized, and interactive pedagogical approaches (Siemens, 2019).

This digital shift is not merely a trend but a fundamental evolution in the educational landscape, driven by the need to meet the demands of a digitally literate generation and the global imperative for lifelong learning. The COVID-19 pandemic further accelerated this transformation, compelling universities to adopt remote learning solutions on an unprecedented scale (Dhawan, 2020). The challenges and opportunities presented by this rapid digitalization have sparked significant academic interest, prompting scholars to explore the implications of digital technologies on pedagogical practices, student engagement, and educational equity (Laurillard, 2021).

However, the integration of digital technologies in university education is not without its challenges. Issues such as digital divide, data privacy concerns, and the need for faculty training have emerged as critical factors influencing the effectiveness of digital learning environments (Selwyn, 2020; Selwyn et al., 2023). Therefore, this article aims to explore the role of digital technologies in transforming university education, examining both the benefits and challenges associated with their implementation. By critically analyzing current literature and case studies, the article seeks to provide insights into how digital technologies are reshaping the educational experience and what this means for the future of higher education.

Literature review

The integration of digital technologies in higher education has been extensively examined through various theoretical frameworks. Siemens (2019) introduced the concept of Connectivism, which argues

that learning in the digital age is fundamentally different from traditional forms, emphasizing the role of technology in creating and managing knowledge networks. Similarly, Laurillard (2021) developed the Conversational Framework, which highlights the interaction between teachers, students, and technology, positing that digital tools can enhance dialogue and feedback loops in the learning process.

Digital technologies have significantly altered pedagogical approaches in university education. The adoption of Learning Management Systems (LMS) like Moodle and Blackboard has facilitated blended and online learning environments, enabling more flexible and accessible learning experiences (Alqahtani & Rajkhan, 2020). Research by Aoun (2017) suggests that the digital shift is fostering a move towards personalized learning, where adaptive learning systems and AI-driven tools provide customized content and feedback to students, thereby improving learning outcomes.

Moreover, MOOCs have democratized access to education, allowing students from around the world to access high-quality courses from leading universities. However, the effectiveness of MOOCs has been debated, with concerns about high dropout rates and the quality of learner engagement (Jordan, 2014). Nevertheless, MOOCs represent a significant step towards the global dissemination of knowledge and the reconfiguration of the traditional classroom.

The impact of digital technologies on student engagement and learning outcomes is a critical area of inquiry. Studies have shown that interactive technologies, such as gamification and virtual reality (VR), can enhance student motivation and engagement (Dichev & Dicheva, 2017). VR, in particular, offers immersive learning experiences that can simulate real-world scenarios, providing students with practical skills and deeper understanding (Merchant et al., 2014).

However, the effectiveness of digital tools in improving learning outcomes is contingent on several factors, including the quality of the content (Kreydun et al., 2022), the design of the learning environment, and the level of student and faculty digital literacy (Bond et al., 2020). Furthermore, research by Selwyn (2020) highlights the importance of considering the socio-cultural context in which digital technologies are deployed, as disparities in access and usage can exacerbate educational inequalities.

Despite the potential benefits, the integration of digital technologies in higher education faces several challenges (Facer &

Selwyn, 2021). One of the primary concerns is the digital divide, which refers to the gap between individuals who have access to digital technologies and those who do not. This divide is often influenced by socioeconomic factors, leading to unequal access to educational resources (Van Dijk, 2020). Moreover, data privacy and security issues have become increasingly important as more educational activities move online. The collection and storage of student data through digital platforms raise ethical concerns about consent, surveillance, and the potential misuse of information).

Another significant challenge is the need for faculty training and support. Faculty members may lack the necessary skills and knowledge to effectively integrate digital tools into their teaching practices. Therefore, professional development programs that focus on digital pedagogy are essential for ensuring that educators can harness the full potential of these technologies (Bates, 2015).

The COVID-19 pandemic has acted as a catalyst for the rapid adoption of digital technologies in higher education (Kreydun *et al.*, 2022). Universities worldwide were compelled to shift to remote learning almost overnight, leading to an unprecedented reliance on digital platforms and tools (Dhawan, 2020). This sudden transition highlighted both the possibilities and limitations of digital learning. On the one hand, it demonstrated the flexibility and scalability of digital education; on the other hand, it exposed the gaps in digital infrastructure, access, and readiness among institutions and students.

Several studies have examined the pandemic's impact on higher education, with mixed findings. While some research indicates that digital learning has been successful in maintaining educational continuity, other studies point to the challenges of student engagement, the digital divide, and the lack of preparedness among both students and faculty (Crawford et al., 2020). The pandemic has thus served as a critical test case for the resilience and adaptability of digital education systems.

Looking forward, the role of digital technologies in university education is expected to expand further, with emerging trends such as Artificial Intelligence (AI), Blockchain, and Big Data analytics poised to revolutionize the sector (Nalyvaiko, 2023). AI can be used to develop intelligent tutoring systems that provide real-time feedback and personalized learning pathways (Holmes et al., 2019). Blockchain technology has the potential to enhance the transparency and security of

academic records and credentials (Sharples & Domingue, 2016). Meanwhile, Big Data analytics can provide insights into student behavior and learning patterns, enabling more informed decision-making at both the instructional and institutional levels (Daniel, 2015).

In conclusion, the literature underscores the transformative impact of digital technologies on university education. While significant progress has been made in integrating these tools into teaching and learning, challenges remain in ensuring equitable access, safeguarding data privacy, and providing adequate support for educators. As digital technologies continue to evolve, ongoing research and innovation will be essential in addressing these challenges and fully realizing the potential of digital education.

Methods

Literature Review

The study commenced with an extensive review of existing literature on the topic of digital technologies in university education. This review aimed to establish a theoretical foundation, identify key trends, and uncover gaps in current research. Relevant academic journals, conference proceedings, books, and credible online sources were examined. The review focused on the evolution of digital tools in higher education, their impact on teaching and learning, and the challenges and opportunities associated with their integration. Sources were selected based on their relevance, publication date, and contribution to the field. The literature review served as a basis for understanding the current state of digital transformation in education and informed the development of the research instruments used in the subsequent phases of the study.

Questionnaires and interviews

To gather empirical data, the study utilized both questionnaires and semi-structured interviews. These instruments were designed to capture the perspectives of teachers and students on the integration of digital technologies into the educational process.

Questionnaires. Two sets of questionnaires were developed—one for teachers and another for students. The questionnaires included both closed-ended and open-ended questions. The closed-ended questions employed Likert scales to measure participants' attitudes towards digital technologies, their usage frequency, perceived benefits,

and challenges. The open-ended questions allowed respondents to provide more detailed insights into their experiences and expectations regarding digital learning. The questionnaires were distributed electronically to a sample of 200 university teachers and 500 students across various disciplines and institutions. The data collected from the questionnaires were analyzed using descriptive and inferential statistics to identify trends and correlations.

The sample size was chosen to ensure a broad range of perspectives from both teachers and students, totaling 200 university teachers and 500 students across various disciplines and institutions. These participants were selected using purposive sampling to ensure that those with direct experience using digital technologies in their educational practices were included. While the sample size was deemed adequate for identifying trends in attitudes and experiences, it is important to note that the study's findings may not fully represent the broader population of higher education institutions at the international level. Further research is needed to confirm the findings in different educational and geographical contexts.

Interviews. In addition to the questionnaires, semi-structured interviews were conducted with a subset of 20 teachers and 30 students who volunteered to participate further. The interviews aimed to explore in-depth their views on the effectiveness of digital tools, the impact on student engagement, and the potential future developments in digital education. The interviews were conducted via video conferencing platforms, recorded with participants' consent, and transcribed for qualitative analysis. Thematic analysis was employed to identify recurring themes and insights, which were then compared with the findings from the questionnaires.

Sample size and selection

The sample size was chosen to ensure a broad range of perspectives from both teachers and students, totaling 200 university teachers and 500 students across various disciplines and institutions. These participants were selected using purposive sampling to ensure that those with direct experience using digital technologies in their educational practices were included. While the sample size was deemed adequate for identifying trends in attitudes and experiences, it is important to note that the study's findings may not fully represent the broader population of higher education institutions at the international

level. Further research is needed to confirm the findings in different educational and geographical contexts.

Study limitations and saturation

One of the limitations of this study is the representativity of the findings at a larger scale. Although the sample included a diverse group of participants from various disciplines, the findings are primarily reflective of the institutions involved in this research. The semi-structured interviews reached data saturation after interviewing 20 teachers and 30 students, where no new significant themes emerged. Nevertheless, the results may be influenced by the specific institutional context and may not fully capture the global or regional diversity in digital education practices. Additional studies with larger and more varied samples could provide further insights into the international applicability of these findings.

Question for AI systems

As part of the study, a novel approach was introduced by surveying three advanced AI systems – ChatGPT, Gemini, and Copilot – on their perspectives regarding the present and future of digital technologies in the educational process. Question was developed to elicit responses from the AI systems. This question focused on their understanding of the current state of digital education, the role of AI in enhancing learning outcomes, and predictions for the future integration of digital technologies in universities. The AI responses were collected and analyzed for content accuracy, relevance, and insightfulness. The responses from the three AI systems were compared to each other and to the data gathered from the human participants. This comparison aimed to assess the alignment between AI-generated insights and human perspectives, as well as to explore the potential of AI as a tool for forecasting trends in digital education. The findings from this AI were integrated into the overall analysis to provide a comprehensive view of the role and potential of digital technologies in transforming university education.

Theoretical background

To conduct a more in-depth analysis of the problem of introducing digital technologies into the university educational process, the theoretical basis should include a comprehensive examination of the

evolution of digital technology adoption in higher education. This can be structured around three key phases: pre-COVID-19, during the COVID-19 pandemic, and post-COVID-19. Each phase reflects different drivers, challenges, and outcomes associated with digital transformation in universities, supported by relevant literature.

Before the COVID-19 pandemic, the integration of digital technologies in university education was largely driven by the growing recognition of their potential to enhance learning outcomes and increase access to education. Universities began adopting Learning Management Systems (LMS), online learning platforms, and various digital tools to complement traditional teaching methods.

Key studies during this period highlighted the gradual shift towards blended learning models, where digital technologies were used to supplement face-to-face instruction (Garrison & Kanuka, 2004). However, the adoption rate was uneven across institutions, with varying levels of faculty engagement and student access. The potential benefits of digital tools, such as increased flexibility and personalized learning, were recognized, but full-scale integration remained limited (Bates, 2015).

The onset of the COVID-19 pandemic in early 2020 forced universities worldwide to rapidly shift to online and remote learning. This period marked an unprecedented acceleration in the adoption of digital technologies, as institutions were compelled to maintain educational continuity amidst widespread campus closures.

Researchers have documented the challenges and innovations that emerged during this period. Dhawan (2020) noted the rapid transition to online learning as a "panacea" during the crisis, but also highlighted the disparities in digital readiness among institutions, faculty, and students. The pandemic underscored the importance of digital infrastructure, faculty training, and student support systems to effectively implement remote learning at scale (Crawford et al., 2020). Despite the challenges, the pandemic period also saw significant advancements in the use of synchronous and asynchronous learning tools, virtual labs, and online assessments.

In the post-pandemic era, universities are reflecting on the lessons learned from the forced digitalization of education and are increasingly moving towards a hybrid model that integrates both digital and traditional learning methods. This period is characterized by a more deliberate and strategic approach to digital technology adoption,

focusing on sustainability, equity, and the enhancement of student engagement and learning outcomes. Recent studies suggest that while some institutions are returning to pre-pandemic practices, many are embracing a hybrid approach, combining the best of online and in-person learning (Hodges et al., 2020). The post-COVID-19 era is also witnessing a growing emphasis on digital literacy for both faculty and students, as well as the exploration of emerging technologies such as artificial intelligence and virtual reality to further enhance the educational experience (Means & Neisler, 2021).

Results

The integration of digital technologies into higher education has been met with both enthusiasm and challenges, as evidenced by the perspectives of university teachers and successful students. The data gathered through semi-structured interviews and surveys reveals a nuanced understanding of how digital tools are influencing the educational landscape. This section analyzes the key themes and insights that emerged from these interviews and surveys, offering a comprehensive overview of the effectiveness, challenges, and potential future developments of digital technologies in academia.

Teachers and students alike acknowledge the transformative potential of digital tools, particularly in enhancing engagement, providing access to diverse resources, and enabling innovative teaching and learning methods. However, they also point to significant obstacles, such as the digital divide, the need for adequate training, and the rapid pace of technological advancement, which require careful consideration and strategic intervention by educational institutions.

In the results, we will delve into the specific findings from these interviews, examining how digital tools are currently being utilized, the impact they have on student engagement, and the perspectives on how these technologies might evolve in the future. This analysis will help to contextualize the role of digital technologies in higher education and inform strategies for their effective integration moving forward. Let's analyze the results obtained

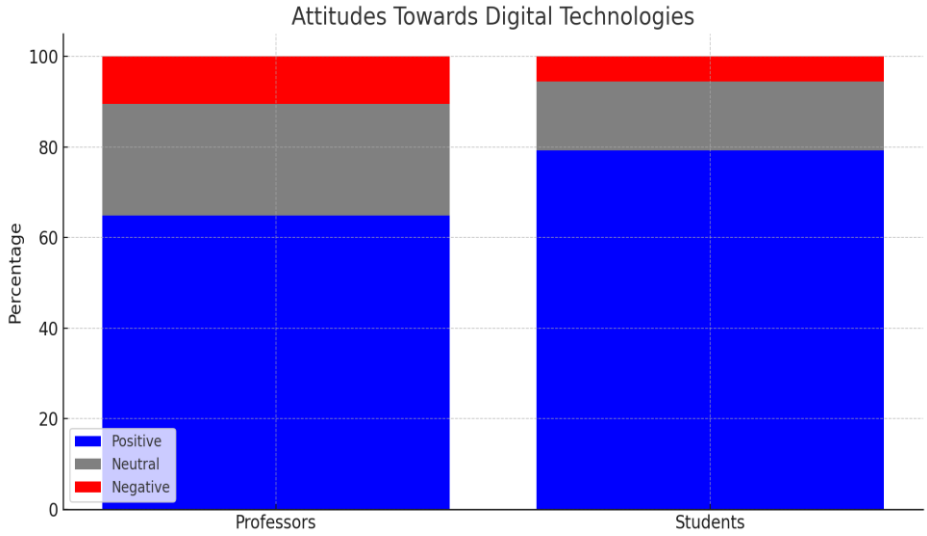

Fig.1. Attitudes towards Digital Technologies

Positive Attitude:
- Professors: 64.8%
- Students: 79.2%

Neutral Attitude:
- Professors: 24.7%
- Students: 15.3%

Negative Attitude:
- Professors: 10.5%
- Students: 5.5%

A majority of both professors and students hold a positive attitude towards digital technologies. However, students are more likely to have a positive view (79.2%) compared to professors (64.8%). A small percentage of both groups remain neutral or negative, with professors showing slightly higher neutrality (24.7%) and negativity (10.5%) than students.

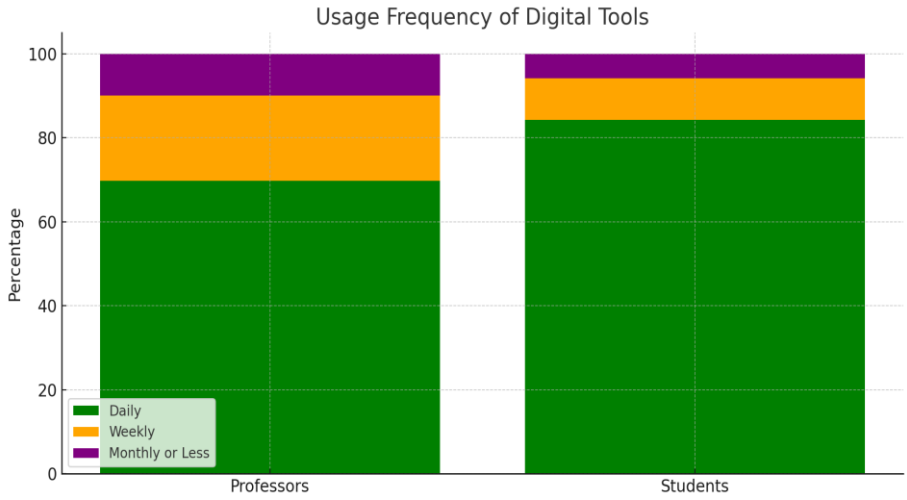

Fig.2. Usage Frequency of Digital Tools

Daily Usage:
- Professors: 69.7%
- Students: 84.3%

Weekly Usage:
- Professors: 20.3%
- Students: 9.8%

Monthly or Less:
- Professors: 10.0%
- Students: 5.9%

Both professors and students frequently use digital tools, with daily usage being predominant, especially among students (84.3%). Professors also show high daily usage (69.7%), but a notable percentage still uses digital tools weekly (20.3%) or even less frequently (10.0%).

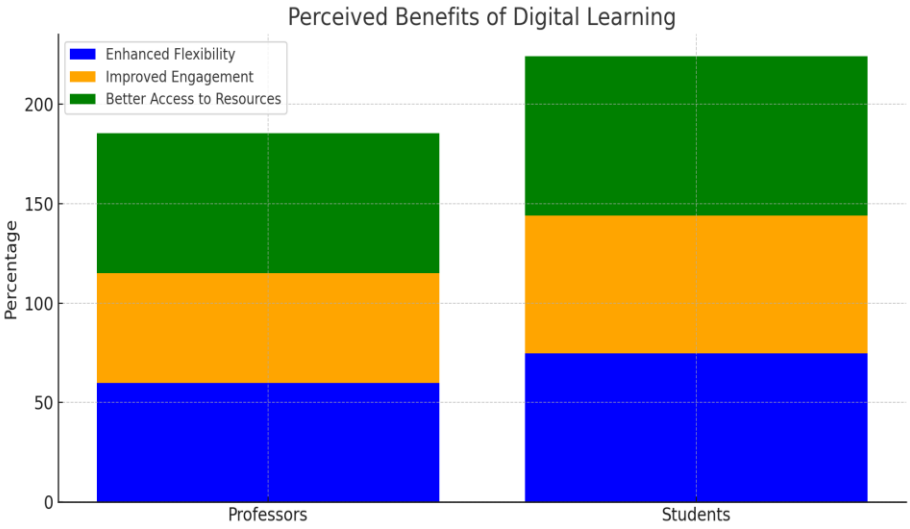

Fig.3. Perceived Benefits of Digital Learning

Enhanced Flexibility:
- Professors: 59.8%
- Students: 74.6%

Improved Engagement:
- Professors: 55.2%
- Students: 69.5%

Better Access to Resources:
- Professors: 70.4%
- Students: 80.1%

The most recognized benefit of digital learning is "Better Access to Resources," particularly among students (80.1%). "Enhanced Flexibility" and "Improved Engagement" are also highly valued, with students consistently rating these benefits higher than professors.

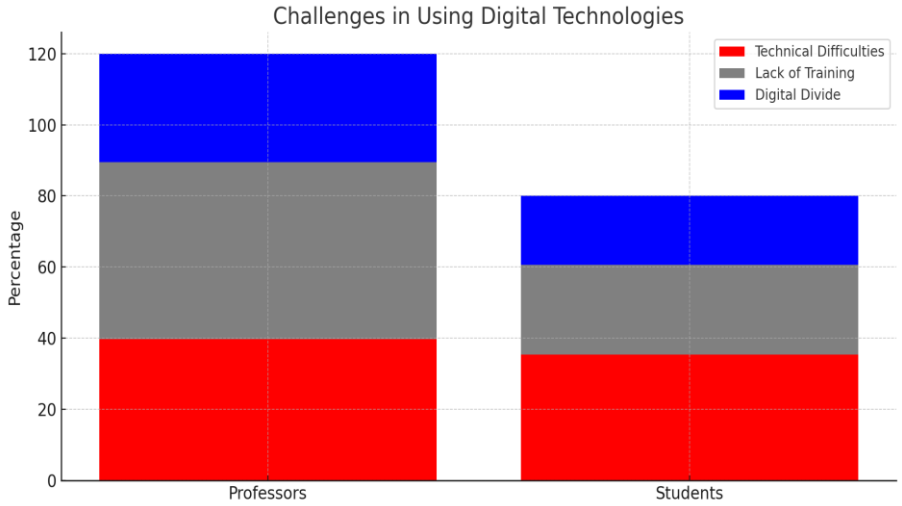

Fig.4. Challenges in Using Digital Technologies

Technical Difficulties:

- Professors: 39.8%
- Students: 35.4%

Lack of Training:

- Professors: 49.7%
- Students: 25.3%

Digital Divide:

- Professors: 30.5%
- Students: 19.3%

"Lack of Training" is the most significant challenge for professors (49.7%), while students are less concerned about this issue (25.3%). Both groups identify "Technical Difficulties" as a challenge, though professors are slightly more affected (39.8%). The "Digital Divide" is also a notable issue, particularly for professors (30.5%). Positive Reception of Digital Technologies a) overall positive attitudes (the majority of both professors (64.8%) and students (79.2%) have a positive attitude towards digital technologies.

This suggests that digital tools are generally well-received and that there is a broad acceptance of their role in modern education); b) student enthusiasm (students are particularly enthusiastic about digital technologies, which may reflect their familiarity and comfort with digital tools, as well as their expectation for modern, tech-enhanced learning environments.

Both professors and students report high daily usage of digital tools, with students leading slightly in this regard. This indicates that digital tools are deeply integrated into the daily academic activities of both groups, reinforcing the central role of technology in contemporary education. Although professors also show significant daily usage, a portion still relies on digital tools on a weekly or less frequent basis. This could suggest a variation in digital literacy or a preference for traditional methods among some faculty members.

The most widely recognized benefit is improved access to resources, particularly among students (80.1%), indicating that digital tools are highly valued for the convenience and breadth of information they provide. Both groups appreciate the flexibility and engagement that digital tools offer, though students perceive these benefits more strongly. This aligns with the modern educational emphasis on personalized learning experiences and interactive content delivery.

A significant challenge identified is the "Lack of Training" for professors (49.7%), highlighting the necessity for ongoing professional development to ensure educators can effectively utilize digital technologies. Both technical difficulties and the digital divide remain obstacles, particularly for professors. These issues suggest the need for better infrastructure, support systems, and equitable access to technology across different socioeconomic groups.

These findings suggest that while digital technologies are generally embraced in university education and offer significant benefits, there are still critical areas that need attention. The strong positive reception among students indicates that universities should continue to invest in and expand their digital offerings to meet student expectations and enhance learning outcomes. However, the challenges identified, particularly related to faculty training and technical difficulties, imply that universities must also focus on supporting their educators and ensuring that technological tools are accessible, reliable, and effectively integrated into teaching practices. Addressing these challenges will be crucial for fully realizing the transformative potential of digital technologies in higher education, ensuring that both students and educators can benefit from the advancements in digital learning.

Thus, for a deeper understanding of the implementation of digital technologies in the educational process of universities, we conducted an interview with teachers and students of universities, which consisted of 5 open questions related to the topic of the study. Below

we will present the questions and analyze the results first among teachers, and then among students. It is important to note that the answers were selected randomly to maintain relevance. This was agreed upon with the research team. *Interview questions for teachers:*

1. How effective do you find digital tools in enhancing the learning experience for students in your courses?
2. What challenges have you encountered in integrating digital technologies into your teaching practices?
3. In your opinion, how have digital tools impacted student engagement and participation in your classes?
4. What potential do you see for the future development of digital technologies in higher education?
5. How do you perceive the balance between traditional teaching methods and digital tools in achieving educational outcomes?

In the context of the study, it is necessary to present and analyze the responses obtained during interviews with university teachers.

Teacher 4:

Question 1: *"I find digital tools to be moderately effective in enhancing the learning experience, especially in providing students with access to a wide range of resources that would otherwise be unavailable. However, the effectiveness largely depends on how these tools are integrated into the curriculum."*

Question 2: *"One of the main challenges I've faced is ensuring that all students have equal access to the necessary technology. The digital divide is real, and some students struggle with reliable internet access or lack the necessary devices."*

Question 3:*"Digital tools have had a positive impact on student engagement in my classes. Tools like interactive quizzes and discussion forums encourage participation, even from students who might be reluctant to speak up in a traditional classroom setting."*

Question 4: *"I believe there is significant potential for digital tools to further personalize learning. AI-driven platforms could help tailor content to individual student needs, making education more adaptive and effective."*

Question 5: *"While digital tools are valuable, I think they should complement rather than replace traditional teaching methods. The personal interaction and hands-on activities in traditional teaching are still crucial for a well-rounded education."*

Teacher 7:

Question 1: *"In my experience, digital tools are highly effective, particularly in delivering technical content. Software simulations and coding platforms provide students with hands-on practice that is essential for understanding complex concepts."*

Question 2: *"The rapid pace of technological change can be challenging. Keeping up with the latest tools and ensuring they are integrated smoothly into the curriculum requires continuous effort and adaptation."*
Question 3: *"I've noticed a marked increase in student engagement since incorporating digital tools. Students are more likely to collaborate online and take initiative in their learning when they have access to interactive and practical resources."*
Question 4:*"I see the future of digital education being driven by AI and machine learning. These technologies could provide real-time feedback and personalized learning experiences that are currently difficult to achieve at scale."*
Question 5:*"For technical subjects like computer science, I believe digital tools are indispensable. However, there's still a need for traditional methods, especially for foundational topics where face-to-face interaction and discussion are beneficial."*

Teacher 12:

Question 1: *"Digital tools are effective in offering diverse learning modalities, which cater to different learning styles. They've been particularly useful in supporting visual and auditory learners in my classes."*
Question 2: *"A significant challenge is ensuring that digital tools are pedagogically sound. Not all tools are designed with educational outcomes in mind, so selecting the right ones requires careful consideration."*
Question 3: *"The impact on student engagement has been mixed. While some students thrive in a digital environment, others seem to disengage, particularly those who struggle with self-regulation and time management."*
Question 4: *"I see potential in expanding the use of virtual and augmented reality in education. These technologies could create immersive learning environments that allow students to explore and interact with content in new ways."*
Question 5: *"There needs to be a balance. Traditional methods are still important for developing critical thinking and communication skills, but digital tools can enhance these by providing additional resources and perspectives."*

Teacher 15:

Question 1: *"Digital tools have been effective in facilitating remote learning, especially during the pandemic. Tools like virtual labs have allowed students to conduct experiments and simulations that would be impossible otherwise."*
Question 2: *"One of the main challenges is the steep learning curve associated with some digital tools. Both students and teachers need time to adapt to new platforms, which can be a barrier to effective implementation."*
Question 3:*"Digital tools have had a positive impact on engagement, particularly in terms of providing instant feedback. Students appreciate the ability to see their results immediately and adjust their learning accordingly."*

Question 4: *"The future lies in integrating more sophisticated simulations and AI-driven tutoring systems that can provide personalized guidance to students, making learning more interactive and tailored to individual needs."*
Question 5: *"A hybrid approach works best. While digital tools are great for simulations and visualizations, in-person lectures and discussions are crucial for developing a deep understanding of physical concepts."*

Teacher 19:

Question 1: *"Digital tools are highly effective for case study analysis and collaborative projects. They enable students to work together in real-time, regardless of their physical location, which is essential in a globalized business environment."*
Question 2: *"Data privacy and security concerns are significant challenges, especially when using platforms that require students to share personal information. Ensuring compliance with regulations and protecting student data is a priority."*
Question 3:*"Engagement has increased, particularly in online discussions and group work. Students seem more willing to participate in digital forums than they might be in a traditional classroom setting."*
Question 4: *"I believe that the future will see more integration of AI-driven analytics tools that can help students understand market trends and business strategies in real-time, making education more relevant and dynamic."*
Question 5: *"Digital tools are essential for business education, but they must be balanced with traditional case studies and face-to-face negotiations to prepare students for the complexities of the real world."*

Summarizing the responses of teachers' interviews on 5 questions allowed us to make the following intermediate conclusions. Teachers generally perceive digital tools as effective in enhancing the learning experience, particularly in providing access to resources, facilitating remote learning, and offering interactive learning modalities. However, the effectiveness is often contingent on how well these tools are integrated into the curriculum. Teachers highlighted several challenges, including the digital divide, inconsistent access to technology among students, the steep learning curve associated with new tools, and the need for continuous professional development. Ensuring pedagogical soundness of digital tools and managing the rapid pace of technological change were also noted as significant hurdles. Digital tools were generally seen to have a positive impact on student engagement, particularly through interactive elements such as virtual labs, simulations, and online discussions. However, some teachers noted mixed engagement levels, with certain students struggling with self-regulation in a digital environment. Teachers see significant

potential in the further development of AI, VR, and AR technologies to create more personalized, immersive, and interactive learning experiences. There is optimism about the role of these technologies in transforming higher education. While recognizing the value of digital tools, teachers emphasized the importance of balancing them with traditional teaching methods. They believe that face-to-face interactions, hands-on activities, and traditional lectures are still crucial for developing critical thinking and deep understanding.

Interview Questions for Students

1. How effective do you find digital tools in enhancing your learning experience in your courses?

2. What challenges have you encountered when using digital technologies in your studies?

3. How have digital tools impacted your engagement and participation in your classes?

4. What potential do you see for the future development of digital technologies in higher education?

5. How do you perceive the balance between traditional learning methods and digital tools in achieving your academic goals?

Student 3:

Question 1: "Digital tools have been extremely effective in my learning process, especially for complex subjects like engineering. The ability to access simulations and online labs has deepened my understanding of difficult concepts that are hard to grasp through textbooks alone."

Question 2: "One challenge is the inconsistency in how different professors use digital tools. Some courses are well-integrated with technology, while others rely too heavily on traditional methods, which can be frustrating when you know there are better digital resources available."

Question 3: "My engagement has definitely increased, particularly with interactive tools like virtual labs and 3D modeling software. These tools allow me to experiment and explore concepts in a way that traditional lectures do not."

Question 4: "I see a lot of potential in further developing VR and AR tools for engineering education. These technologies could offer even more immersive experiences, allowing us to 'build' and 'test' projects in a virtual environment before moving to physical prototypes."

Question 5: "I believe there needs to be a strong integration between the two. While digital tools offer new ways to learn and practice, the

foundational understanding often comes from traditional lectures and textbooks."

Student 14:

Question 1: "Digital tools have been very effective, especially for real-time collaboration on group projects. Tools like shared documents, virtual whiteboards, and business simulation software have enhanced our ability to work together efficiently, regardless of our locations."

Question 2: "A major challenge is the overwhelming amount of digital resources available. It can be difficult to determine which tools are most effective, and sometimes, there's a lack of guidance on how to use them effectively."

Question 3: "Digital tools have significantly increased my engagement, especially in online discussions and simulations. The interactive nature of these tools makes learning more dynamic and keeps me more involved in the process."

Question 4:"I believe the future lies in AI-driven analytics tools that can provide us with real-time market data and insights, which would be invaluable for case studies and developing business strategies during our studies."

Question 5: "While digital tools are essential for modern business education, traditional methods like case studies and in-person presentations are still crucial for developing critical thinking and soft skills."

Student 22:

Question 1: "In medicine, digital tools have been incredibly effective, especially in terms of virtual dissections and diagnostic simulations. These tools allow us to practice in a risk-free environment, which is essential for building confidence and competence."

Question 2:

"The biggest challenge is the occasional disconnect between digital tools and the reality of clinical practice. While simulations are helpful, they can't fully replicate the nuances of patient interactions and real-world conditions."

Question 3: "My engagement has increased, particularly with tools that simulate clinical scenarios. These tools help me apply theoretical knowledge to practical situations, making the learning process more interactive and relevant."

Question 4: "I see great potential in AI-driven diagnostics and personalized medicine tools. These technologies could revolutionize

medical education by providing students with real-time feedback and tailored learning experiences."
Question 5: "Both are essential. Traditional methods like in-person labs and patient simulations provide hands-on experience that digital tools can't fully replicate, but digital tools offer additional practice and depth that enhance our overall learning."

Student 24:

Question 1: "Digital tools have been highly effective in expanding my access to a wide array of resources, including online archives, digital libraries, and multimedia content, which are crucial for my research and creative projects."
Question 2: "One challenge is the sometimes overwhelming nature of digital resources. It can be difficult to focus when there is so much information available, and managing digital distractions is a constant struggle."
Question 3: "My engagement has been enhanced through digital tools that allow for interactive and multimedia-based learning. For instance, tools that let me create and analyze digital art have made the creative process more engaging and accessible."
Question 4:"I think there's a lot of potential in expanding digital storytelling tools and virtual galleries, which would allow us to present our work in innovative ways that reach wider audiences."
Question 5: "For the arts and humanities, there needs to be a balance. While digital tools offer new creative possibilities, the foundational skills and critical analysis taught through traditional methods are irreplaceable."

Student 28:

Question 1: "As a computer science student, digital tools are integral to my education. They're extremely effective, particularly for coding practice, software development, and algorithm visualization. These tools are essential for mastering the technical skills required in my field."
Question 2:
"The main challenge is keeping up with the rapid pace of technological change. New tools and languages are constantly emerging, and it can be difficult to stay current with everything while also managing coursework."
Question 3: "Digital tools have significantly boosted my engagement. Interactive coding platforms and collaborative development environments allow me to experiment and learn in a hands-on way, which is far more engaging than traditional lectures."

Question 4: "I see enormous potential in AI and machine learning tools that could assist in code optimization and debugging. These technologies could transform how we approach software development, making the process more efficient and intuitive."
Question 5: "In computer science, digital tools are essential, but there's still value in traditional methods, particularly when it comes to understanding the underlying theories and principles. A strong theoretical foundation is necessary to effectively use and innovate with digital tools."

Summarizing the responses of students' interviews on 5 questions allowed us to make the following intermediate conclusions. Students across various departments view digital tools as highly effective in enhancing their learning experience. These tools provide opportunities for hands-on practice, collaboration, and access to a vast array of resources, which are particularly valuable in technical and creative fields. Students identified challenges such as the overwhelming abundance of digital resources, inconsistencies in how professors use digital tools, and the difficulty of staying updated with rapidly changing technologies. Managing digital distractions and ensuring that digital tools align with real-world practices were also noted as concerns. Students reported increased engagement due to the interactive nature of digital tools. They appreciated the ability to experiment, collaborate, and receive immediate feedback, which enhanced their involvement and interest in their studies. Students see significant potential in AI-driven analytics, VR, AR, and other advanced technologies to further personalize and enhance learning. They envision these tools playing a key role in making education more adaptive, relevant, and immersive. Like the teachers, students believe in the importance of balancing digital tools with traditional methods. They value the foundational skills and in-person experiences provided by traditional education, which they see as complementing the benefits of digital tools.

Both teachers and students recognize the significant role that digital tools play in modern education, particularly in enhancing engagement, providing access to resources, and facilitating new learning modalities. However, there is a shared understanding that these tools should complement rather than replace traditional methods. The challenges identified, including the digital divide, the need for continuous professional development, and the rapid pace of technological change,

highlight areas where universities must focus their efforts to fully realize the potential of digital technologies in higher education.

The potential for future developments in AI, VR, AR, and personalized learning technologies is viewed with optimism by both groups, suggesting a promising direction for the evolution of digital education. However, the importance of maintaining a balanced approach, integrating both digital and traditional methods, is emphasized as crucial for achieving comprehensive educational outcomes.

The rapid evolution of digital technologies, particularly during and after the COVID-19 pandemic, has undeniably reshaped the landscape of higher education. As universities increasingly integrate these technologies into their educational frameworks, it becomes imperative to explore not only human perspectives—those of educators and students—but also the insights offered by advanced artificial intelligence systems.

Artificial intelligence (AI) has emerged as a critical tool in this digital transformation, offering capabilities that extend beyond mere automation to include personalized learning, predictive analytics, and enhanced student engagement. Given the role of AI in both shaping and responding to the needs of modern education, its perspective on the future trajectory of digital learning is of profound importance.

AI systems, such as those employed in this study, can analyze vast amounts of data, identify trends, and provide predictive insights that are invaluable for educators and policymakers. By incorporating AI's perspective, we gain a deeper, data-driven understanding of the potential paths for integrating digital technologies into university education. This not only enriches the analysis but also helps in forecasting the challenges and opportunities that lie ahead, ensuring that the digital transformation of education is guided by both empirical evidence and advanced technological foresight.

We will explore the forecasting provided by AI systems alongside those of human participants, highlighting the unique contributions that AI can offer in understanding and shaping the future of digital education. This holistic approach is crucial for developing a comprehensive strategy for the effective and sustainable integration of digital technologies in higher education.

Our research question for the selected AI systems was formulated as follows: *How do you foresee the impact of digital technologies as a factor in transforming learning in university education now and in the near future?*

When analyzing the three answers in the specific context of the use of digital technologies in the educational process of universities, both now and in the near future, each response highlights different aspects and approaches to this transformation (see Tab.1).

Tab.1. Analysis of AI responses

№	ChatGPT's Answer	Gemini's Answer	Copilot's Answer
1	Focus on Current and Future Trends: This response provides a comprehensive analysis of how digital technologies are currently being used in universities and how they are likely to evolve. It covers specific areas such as personalized learning, data-driven decision-making, and the emergence of new pedagogical models.	Broad Overview with Specific Trends: This response highlights key areas such as enhanced access, personalized learning, and new pedagogical approaches, similar to ChatGPT. However, it also places a significant emphasis on challenges such as the digital divide and data privacy, which are crucial in the context of widespread technology adoption in education.	Engagement with the Present and Speculation on the Future: This answer creatively captures the ongoing changes in university education due to digital technologies, particularly how the pandemic accelerated these changes. It discusses the current use of technologies like video conferencing and interactive tools, while also speculating on future developments in a more narrative style.
2	Practical Implications: The response thoroughly examines how digital technologies are reshaping various aspects of the educational process, from student learning experiences to faculty roles. It emphasizes the gradual shift towards more personalized and inclusive learning environments.	Balance of Current and Future: The analysis provides a balanced view of both the current state and future trends, focusing on the practical implementation of digital technologies in university education. The mention of lifelong learning and micro-credentials points to the evolving nature of education, which will likely extend beyond traditional degree programs.	Metaphorical Approach: The use of metaphors and creative language makes the discussion more accessible but might lack the specificity and detail needed for a more in-depth analysis. The mention of the "eight dimensions of learning" and "learning ecosystems" indicates a recognition of the complexity of digital transformation but without deep exploration.

3	Near-Future Vision: The prediction of further advancements in AI, VR/AR, and ethical considerations suggests a continued evolution towards more sophisticated, technology-driven educational processes. This vision is practical and rooted in current technological trends.	Challenges and Considerations: By discussing the challenges, this response provides a realistic view of what universities must consider when integrating digital technologies into their processes.	Focus on Adaptation and Innovation: The emphasis on the need for universities to keep "dancing" with technology underlines the ongoing, dynamic nature of this transformation. The response suggests that while technology plays a crucial role, the success of its integration depends on how well institutions can adapt and innovate.

Thus, we can say that ChatGPT's Answer offers a detailed, structured analysis ideal for understanding both the current and future impacts of digital technologies in university education. It's well-suited for academic discussions or strategic planning in educational institutions; Gemini's Answer provides a balanced overview, emphasizing the practical aspects of current technology use while also addressing potential future challenges. It's suitable for stakeholders looking for a realistic and actionable analysis; Copilot's Answer delivers a more engaging, narrative-driven take on the subject, focusing on the ongoing adaptation to digital technologies. While less detailed, it's useful for those who prefer a more creative and less formal discussion of the topic. In the context of understanding the use of digital technologies in university education, ChatGPT and Gemini provide more comprehensive and directly applicable insights, while Copilot adds a creative perspective that could inspire innovative thinking about the future of digital education.

Discussions

The study findings align with the broader literature that recognizes the transformative role of digital technologies in higher education. The adoption of Learning Management Systems (LMS) and other digital tools has significantly expanded access to educational resources, enabling more flexible and student-centered learning environments. According to Garrison & Kanuka (2004), blended

learning, which combines online and face-to-face instruction, has uncovered transformative potential by offering both flexibility and the depth of traditional methods. This study reaffirms the importance of digital tools, particularly in the context of the COVID-19 pandemic, which accelerated the adoption of these technologies on a global scale (Dhawan, 2020).

Despite the benefits, the integration of digital technologies is fraught with challenges, a point extensively discussed in the literature. Bates (2015) highlights the uneven adoption of digital tools across institutions, often due to disparities in digital literacy among faculty and students, as well as infrastructural limitations. The digital divide, a term referring to the gap between those with easy access to technology and those without, remains a significant barrier to equitable education (Van Dijk, 2020). The challenges identified in this study echo these concerns, suggesting that universities must adopt a strategic, inclusive approach to overcome these obstacles and ensure that digital transformation benefits all students and faculty.

The potential for future developments in digital education is a recurring theme in both the study findings and the existing research. Emerging technologies such as AI, VR, and AR are poised to further transform educational practices, offering new ways to engage students and personalize learning experiences. Holmes et al. (2019) emphasize the role of AI in providing real-time feedback and adaptive learning paths, which can cater to the individual needs of students. This study supports the view that the future of digital education lies in harnessing these technologies to create more interactive and personalized learning environments.

The balance between digital tools and traditional teaching methods is a key consideration in the effective integration of technology in education. Laurillard (2021) argues that while digital tools can enhance learning, they should complement rather than replace traditional methods. The study's findings indicate that both teachers and students value the interactive and flexible nature of digital tools but recognize the importance of maintaining traditional educational practices, such as face-to-face interaction and hands-on learning, to develop critical thinking and practical skills.

The inclusion of AI perspectives in this study underscores the growing importance of AI in educational contexts. AI's ability to analyze large datasets, identify trends, and offer predictive insights is increasingly

seen as a valuable asset for educational institutions (Luckin et al., 2016). By incorporating AI into the strategic planning of digital education, universities can make data-driven decisions that enhance teaching effectiveness and student outcomes. This study contributes to the understanding that AI is not just a tool for learning but also a critical element in shaping the future of education.

The findings highlight the need for robust policy frameworks and infrastructure development to support the sustainable integration of digital technologies. Means & Neisler (2021) discuss the importance of digital infrastructure in ensuring that all students have access to the necessary tools and resources for learning. Additionally, Hodges et al. (2020) distinguish between emergency remote teaching during the pandemic and true online learning, emphasizing the need for well-thought-out policies and infrastructure to support long-term digital education strategies.

Conclusions

This study has provided a comprehensive analysis of the role of digital technologies as a transformative factor in university education, drawing on empirical data from interviews with teachers and students, as well as AI-generated insights. Several key conclusions can be drawn from this research:

1. Both university teachers and students generally perceive digital technologies as effective tools that enhance the learning experience. These tools have been particularly valuable in expanding access to resources, facilitating remote learning, and supporting diverse learning modalities.

2. Despite the positive reception, significant challenges remain in the integration of digital technologies. These include the digital divide, which affects equitable access to technology, the steep learning curve for both students and faculty, and the need for continuous professional development to ensure effective use of these tools.

3. Digital technologies have positively impacted student engagement, particularly through interactive and practical tools like virtual labs, simulations, and online discussions. However, some students still struggle with self-regulation in a digital learning environment, indicating a need for balanced approaches.

4. There is strong optimism about the future potential of emerging technologies such as AI, VR, and AR in further transforming

higher education. These technologies are expected to enable more personalized, immersive, and interactive learning experiences, which can significantly enhance educational outcomes.

5. The study emphasizes the importance of balancing digital tools with traditional teaching methods. While digital technologies offer numerous advantages, traditional methods such as face-to-face interaction and hands-on activities remain crucial for developing critical thinking and practical skills.

6. The inclusion of AI perspectives highlights the growing importance of AI in shaping the future of education. AI's ability to provide data-driven insights and predictions can help universities make more informed decisions about the integration of digital technologies, ensuring that these tools are used effectively to enhance both teaching and learning outcomes.

7. The findings underscore the need for robust policy frameworks and infrastructure development to support the sustainable integration of digital technologies in higher education. This includes ensuring that all students have access to the necessary tools and resources and that there are well-thought-out policies to support long-term digital education strategies.

In conclusion, while digital technologies have already made significant inroads into higher education, their full potential has yet to be realized. Addressing the challenges identified in this study and continuing to innovate in the use of emerging technologies will be crucial for universities to fully harness the transformative power of digital tools in education.

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