SCIENTIFIC REVIEW

THE DIGITALISATION AND ITS ROLE IN EDUCATION

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ABSTRACT

In recent decades, the digital revolution has brought major changes to education, accelerated by the rise of smart boards, e-learning, virtual reality, and 3D printing. A variety of devices have emerged, from projectors replacing overhead projectors to smartphones supplanting calculators. Nevertheless, digital literacy varies across regions and age groups and is influenced by infrastructure, access, and the state of the education system. Digital technologies have been adopted in education, but their utilisation demands appropriate instruction and continuous enhancement for educators and students alike. The COVID-19 pandemic has accelerated the integration of digital tools, but their adoption has encountered various challenges. Along with the advantages of digital education, potential issues such as accessibility, technical barriers, and diminished interactivity also arise. To achieve successful implementation of digital education, it is crucial to maintain a balance, ensure data protection, and provide continuous training to teachers.

Keywords: *digitalisation, education, COVID-19, digital technologies*

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INTRODUCTION

The digital revolution has had a huge impact on our daily lives [1], [2], and education is no exception. The emergence of digital technologies has revolutionised education, transforming the learning process for both teachers and students. From smart boards to online learning materials, from virtual reality applications to 3D printing, a range of tools and technologies have become part of the educational process.

Decades ago, overhead projectors were introduced as the first digital tools in education, and they were used for decades. These projectors offered a significant advantage over the chalkboard because they allowed for the creation and presentation of more complex diagrams. Instructors did not need to undergo any training to use them. On the other hand, course notes had to be prepared on transparencies, which meant a lot of extra work. A further difficulty was that these machines were often not installed and therefore had to be moved by the teachers. Over the years, improvements led to the production of more compact machines that could be folded into a bag. Repairing or modifying them (the foil had to be remade) was difficult.

A disadvantage compared to the blackboard was that only the final result (including the deduction) was seen in one step, so the solution process was less memorised by the students.

Overhead projectors were essentially retired with the advent of the projector in the early 2000s. Using a projector, either with a computer or just a storage device, we could now share video files and content with the audience.

At the same time, or perhaps even earlier, we should mention calculators and computers. The use of computers first appeared in research, then in industry, and finally in education. Calculators, which have been in use for many decades since replacing the slide rule, have also been an integral part of education. However, because they were introduced before the IT revolution, they are not really considered part of digital education. Still, we use these tools daily, but now not as stand-alone devices, rather as apps on our smart devices (mobile phones).

Nowadays, the development of digital tools has accelerated enormously, and new digital tools are increasingly appearing in education. For instance, SmartTextbooks (NKP) [3] provide digital access to information as well as opportunities for practising examples, working in pairs, and accessing audio and video content.

Digitalisation has also made it possible to conduct exams in digital form, including make-up exams. Additionally, online exercises allow for automatic correction and immediate feedback for both teachers and learners.

It is important to note that technological development without education and training is ineffective. The continuous development of technology means that further training and lifelong learning must be ensured. Experience has shown that people often stop developing further after leaving school or university, becoming stuck at a certain level [4].

The aim of this study is to provide a comprehensive overview of the current state of digitalisation in education and its potential for further development and use.

GEOGRAPHICAL DISTRIBUTION OF DIGITAL COMPETENCES

Digital competence refers to an individual's or group's ability to navigate and interact with the digital environment effectively. This includes the ability to use and interpret information, communicate through digital means, and critically evaluate and create content in the digital world. Digital literacy encompasses technical knowledge and skills, such as the use of hardware and software, the ability to search for and evaluate information, awareness of privacy and digital security, and the ability to communicate and collaborate online. It is crucial for an individual's personal and professional development, as well as for social and economic participation.

Digital competence varies across regions and geographical areas. These disparities arise from various factors, including economic development, educational systems, infrastructure, and cultural context. For instance, wealthier countries tend to be better equipped with digital tools and technologies and have a broader range of digital skills among their population. In contrast, less affluent areas may have limited digital skills due to inadequate infrastructure and poor accessibility. Countries with a high level of IT

education are more likely to have students with strong digital skills. When digital teaching and learning are well-established within an educational system, students are better equipped to handle digital challenges. These factors together influence the prevalence and development of digital competences within a given region or country. Understanding such regional disparities helps inform the creation of more targeted and effective digital education and development strategies.

The correlation between digital expertise and the size of a town or city can be complex and variable. Numerous factors may influence this relationship, and it may not always be apparent. Several key aspects should be considered. In general, larger cities have better access to broadband internet and other digital tools. Therefore, cultivating digital proficiency is likely easier in larger urban areas. In metropolitan environments, educational infrastructure tends to be more advanced, incorporating digital teaching and learning technologies that facilitate the development of students' digital capabilities. This supports the growth of these skills and increases the number of job opportunities available [5].

AGE DIFFERENCES IN DIGITAL COMPETENCES

Age-related differences in digital competences can result from a variety of factors, highlighting the importance of understanding these variations in order to create effective educational and support strategies [6]. Several critical aspects may influence differences in digital competence across age groups. The so-called digital natives from younger generations grow up in an environment where using digital technologies is a part of daily life. Therefore, younger individuals may demonstrate greater intuition in using digital tools. In contrast, older individuals, who were not exposed to digital devices earlier in life, may be less adept at using them [7]. Availability and accessibility are crucial, as those without access to technology are less likely to develop digital competences. Younger individuals have been educated with digital technologies, while older generations often relied on more traditional learning methods. Generation Z, also known as digital natives, has a distinct attitude towards information and communication technologies (ICT) [8]. As a result, younger generations may find it easier to adapt to new technologies. The motivation to improve digital competences can also vary between age groups. For younger people, the drive to communicate, be entertained, and learn online may be stronger, while for older individuals, the key motivation may lie in using digital tools for specific, practical purposes.

Younger generations tend to have different attitudes and are often more open and willing to try new technologies, whereas older generations may be more hesitant or resistant. This can be attributed to differences in lifestyles and usage habits: younger people typically use technology for communication and leisure activities, while older people are more likely to use digital tools for specific functions and tasks.

The above suggests that the development of digital skills depends on both educational and socio-cultural factors. To foster digital competence effectively, it is important to acknowledge and understand age differences and to apply flexible teaching methods tailored to the needs of different age groups.

THE ROLE OF DIGITAL TECHNOLOGIES IN EDUCATION

Digitalisation in education involves not only the use of tools and technologies but also teaching methods focused on learning and teaching in a digital environment. These methodologies include online learning platforms, distance learning, adaptive learning systems, and interactive digital learning materials. The integration of digital tools and technologies is essential for the comprehensive transformation of educational processes and strategies.

Digitalisation in education encompasses the use of information and communication technologies (ICT) in educational practices and tools. This includes the digitisation of educational materials and their availability in electronic format, online learning platforms and courses, interactive learning tools and applications, distance learning, and e-learning. Digitalisation has enabled education providers to offer more flexible access to educational content and tools, thereby increasing the efficiency and accessibility of education. It is often combined with traditional teaching methods to enhance learning and instruction through digital means [10].

Digital technologies offer a wide range of tools and applications for education, from smart boards and presentation tools, online learning materials, and e-learning platforms, to virtual and augmented reality,

smartphones, and data management systems. These tools help make the learning process more interactive and effective for both teachers and students.

Smart boards and presentation devices allow teachers to deliver interactive lectures while providing students with a visual and engaging learning experience. Online course materials and e-learning platforms offer flexible learning opportunities, while virtual reality (VR) and augmented reality (AR) provide realistic learning environments.

With the widespread use of smartphones and tablets, students can easily access information and learning materials anytime and anywhere. The use of smartphones allows students to take advantage of downtime during travel (e.g., for language learning or listening activities). Furthermore, smartphones serve as calculators and enable rapid access to needed content regardless of location or external conditions. They can also be used to capture information that is available for a limited time [11].

In essence, digitalisation in education refers to the application of ICT in educational processes and tools. It includes, for example, the digitisation of educational materials and their availability in electronic format, online learning platforms and courses, interactive tools and applications, distance learning, and e-learning. Digitalisation enables more flexible access to educational content and tools, thus improving the effectiveness of learning. It is usually implemented alongside traditional teaching methods to enhance the educational experience through digital technologies.

OPPORTUNITIES IN DIGITAL EDUCATION

Digital education is highly versatile and offers numerous opportunities to improve and modernise educational processes. Digital technologies create a range of possibilities, including facilitating communication and collaboration, increasing accessibility and flexibility, supporting diverse learning styles, and providing personalised learning experiences. Digital platforms allow learners to study at their own pace and engage with content according to their preferences, thus addressing individual learning needs and styles. For example, Duolingo is a free language-learning app that offers instruction in several languages (English, German, French, Italian, Spanish, Portuguese, etc.), especially for younger learners (featuring a friendly owl that greets and guides users). It combines research-based teaching methods with engaging content and effectively develops writing, speaking, reading, and listening skills. It is excellent for classroom use, as well as at-home preparation—even in a differentiated context—as lessons are personalised, allowing everyone to progress according to their own level and ability. The app also enables learners to test their knowledge with reliable accuracy or compare results with peers through its platform. The Kahoot application is also increasingly popular in language education. It allows educators to set prerequisites for tasks so that students can only proceed if they demonstrate sufficient knowledge, while still allowing multiple attempts. This fosters an individualised pace of learning tailored to each student's knowledge and abilities.

These tools support various learning styles, including visual, auditory, and interactive preferences. Digital education facilitates flexible learning by providing access to materials without constraints of time or location. Teachers can offer personalised experiences that adapt to each student's pace and needs. A key advantage is that such resources can be accessed almost anytime—or during a designated time window set by the instructor (e.g., for a quiz).

Digital technologies also enhance online communication and collaboration, simplifying interactions between students and teachers. These capabilities bring education into the digital era and enrich the learning experience. Digital learning platforms enable participation from students who cannot be physically present in class, expanding access to education.

Educators now have the opportunity to develop interactive teaching methods, including online presentations, interactive exercises, and educational videos. Digital tools contribute to collaborative learning environments where students and teachers can easily share information, ideas, and projects. Platforms like Padlet support such collaboration, allowing users to post schedules, share portfolios, comment (with moderation if necessary), and even schedule posts in advance.

Data management and analysis tools help educators assess teaching effectiveness and optimise instructional strategies. For example, the Slido app can be used during lectures to conduct live polls via smartphones, allowing for immediate feedback on student understanding. Results are available in real time.

THE ROLE OF 3D PRINTING IN EDUCATION

3D printing provides a unique dimension to education by offering realistic models and prototypes that aid in the comprehension of abstract concepts, such as those found in biology or engineering, as illustrated in Figure 1.

Fig. 1: Teaching aid created by 3D printing [12]

Furthermore, 3D printing fosters creativity and design skills, as students are able to create and implement their own designs [13], [14], [15]. Thus, 3D printing functions not only as a tool but also as a means of enhancing students' technical abilities [16], [17].

CHALLENGES AND REQUIREMENTS FOR THE USE OF DIGITALISATION IN EDUCATION

Digital education also presents many challenges. It is essential for both students and teachers to continuously develop their digital competence in order to use these tools effectively [18].

All students and teachers should have access to appropriate infrastructure and equipment. Teachers need to adapt to new technologies and develop lesson plans that effectively incorporate digital tools for educational purposes.

Teachers play a crucial role in the digital learning environment. They must be prepared to utilise digital technologies and continuously improve their digital competencies. Educational institutions must ensure they provide adequate support, time, materials, equipment, and human resources to train teachers and enable the effective use of digital learning tools [19].

Future trends include the rise of adaptive learning content that offers personalised educational experiences [20], as well as the continued development of virtual and augmented reality applications [21], which create realistic and interactive learning environments [22].

The spread of AI and automated assessment could further facilitate the evaluation of student performance (e.g., Moodle, Grader), while distance and hybrid education may become even more relevant—especially in an era of globalisation and digitalisation. In addition, the advancement of interactive teaching tools and applications could provide new opportunities for teaching and learning [23].

A significant number of research studies explore which areas of trainers' digital competence are adequately covered and where gaps remain to be addressed [7].

Educational institutions must also comply with strict data protection and security standards for their online activities.

However, it is important to maintain a sense of balance in this digital transformation of education. Teachers and students need sufficient time and support to use digital tools effectively and intentionally. Education is still fundamentally based on human relationships and individual development, and digital technologies should complement—rather than replace—these core elements.

Although various technological devices expand the methodological possibilities available to teachers, effective education depends primarily not on the technology itself, but on the teacher. It is possible to deliver a great interactive lecture with an overhead projector, to develop skills through a gamified experience without any devices, or to deliver a boring and unclear lecture using high-tech equipment. Perhaps the most optimal results are achieved by supplementing and enriching traditional frontal teaching. As long as a digital tool is still perceived as novel, it keeps the audience engaged—therefore, it is not advisable to use it continuously.

THE IMPACT OF COVID-19 ON THE DIGITISATION OF EDUCATION

The COVID-19 pandemic brought significant changes to education, particularly in the increased reliance on digital tools. The following are examples of how the pandemic has influenced the use of digital tools across various educational areas:

- Due to closures and social distancing measures, educational institutions were forced to rapidly transition to distance learning.
- This led to the widespread adoption of online learning platforms, video conferencing tools, and other digital applications such as Zoom, Microsoft Teams, and Google Meet.
- Some school systems began replacing traditional textbooks with digital learning materials, allowing students to access content from home. The use of e-books and online libraries increased, making home-based learning more accessible.
- Educational institutions had to implement systems for conducting online exams and grading to ensure learning continuity. This required the development of secure identification methods and strategies to prevent cheating and unauthorised collaboration.
- Teachers had to acquire the skills to effectively use online tools and adapt to the requirements of remote instruction.

The COVID-19 pandemic significantly transformed the way education is delivered, presenting challenges for both teachers and students. However, with the help of digital tools, educational institutions were able to quickly adapt and continue the learning process. It is expected that digital education and the associated use of technology will continue to play an increasingly important role in the future of education.

THE DISADVANTAGES OF USING DIGITAL TOOLS IN EDUCATION

Naturally, the introduction of digital tools brings both advantages and disadvantages. Therefore, it is essential to consider the challenges and limitations of using such tools. Below are several examples of common disadvantages:

- Not all students have sufficient access to devices and digital resources, contributing to the digital divide.
- Technical issues, such as internet connectivity problems or device malfunctions, can disrupt continuous learning [24].
- Excessive screen time may negatively affect students' physical and mental health.
- Digital education can reduce interaction between instructors and students, as well as among peers.
- The use of digital tools can raise concerns regarding the privacy and security of personal data.
- Educators may not always receive adequate training and support to use digital tools effectively.

- The abundance of misinformation online can make it difficult for students to identify relevant and reliable information.
- Grading certain types of assignments—such as drawings or complex visuals—can be more difficult in digital format, often requiring additional tools or resources.
- Creating digital content often involves significant extra work for teachers.
- Teachers must continuously improve their digital competences and frequently attend training sessions and workshops due to the rapid evolution of digital tools.
- With the rise of artificial intelligence (AI), educators will need to adapt their assessment methods and be prepared to detect non-original responses generated by tools such as chatbots (e.g., GPT).

It is crucial to understand that the advantages and disadvantages of digital tools are deeply interconnected. Educational institutions must consider both in order to achieve optimal results. A balanced approach can help ensure the effective and responsible use of digital learning technologies.

SUMMARY AND CONCLUSIONS

The digital revolution has profoundly impacted various sectors, including education, where the integration of digital technologies has transformed traditional learning processes. Initially, tools such as overhead projectors marked the beginning of this digital transition, offering advantages over conventional methods despite certain logistical limitations. Over time, more sophisticated technologies—such as computers, calculators, and more recently, smart devices—have become integral to the educational process.

Digital competence, defined as the ability to effectively navigate and interact with digital environments, varies significantly across regions and age groups. Wealthier areas with robust infrastructure generally exhibit higher levels of digital competence compared to less developed regions. Additionally, younger generations—often referred to as digital natives—tend to demonstrate greater proficiency due to early and sustained exposure to digital tools, while older individuals may face more difficulty in adapting to technological changes.

Digitalisation in education encompasses a wide range of technologies, including smart boards, online learning platforms, virtual reality (VR), and augmented reality (AR), all of which enhance interactivity and accessibility. These tools accommodate various learning styles and enable personalised educational experiences, making learning more flexible and tailored to individual needs.

Furthermore, 3D printing has emerged as a valuable educational tool, enabling students to create tangible models that support the understanding of complex concepts while fostering creativity and technical skill development. However, successful integration of digital technologies in education requires the ongoing development of digital competences among both students and teachers. This process depends on sufficient infrastructure, targeted training, and institutional support.

Despite the numerous benefits, the use of digital tools in education also presents notable challenges. These include unequal access to technology, technical disruptions, extended screen time, and data privacy concerns. Additionally, the overall quality of digital education depends heavily on teachers' ability to integrate these tools effectively into their instructional methods.

The COVID-19 pandemic has significantly accelerated the adoption of digital technologies in education, prompting institutions to swiftly transition to online learning platforms and digital content. This shift has demonstrated both the vast potential and the limitations of digital education. While it has allowed learning to continue during periods of lockdown, it has also exposed issues such as the digital divide and the need for reliable infrastructure and comprehensive training.

In conclusion, the digitisation of education offers numerous opportunities to enhance learning through increased interactivity, flexibility, and personalisation. However, to fully realise its potential, it is essential to maintain a balance between digital and traditional teaching methods in order to preserve the human element central to education. Addressing the challenges associated with digital tools and ensuring equitable access and ongoing skills development are key factors in the successful advancement of digital education.

REFERENCES

[1] Ficzere, P. (2023). The role of artificial intelligence in the development of rail transport. Cognitive Sustainability. https://doi.org/10.55343/cogsust.81

[2] Stalmasekova, N., & Fabus, J. (2023). Integrating Sustainability: Unveiling the Quadruple Helix - A Study on Pre-development of Smart City Strategy . Cognitive Sustainability, 2(4). https://doi.org/10.55343/cogsust.84

[3] https://www.nkp.hu/

[4] Misik, T., Stofkova, J., & Stalmasekova, N. (2018). Survey of increasing digital skills of university students. In ICERI2018 Proceedings (pp. 3949-3956). IATED., doi: 10.21125/iceri.2018.1879

[5] Genzorova, T., Corejova, T., & Stalmasekova, N. (2019). How digital transformation can influence business model, Case study for transport industry. Transportation Research Procedia, 40, 1053-1058., https://doi.org/10.1016/j.trpro.2019.07.147

[6] Dorner, L., Hatvani, A., Taskó, T., Soltész, P., Estefánné Varga, M., & Dávid, M. (2016). IKT-használat 10–18 éveseknél egy ikt-eszközhasználati kérdőív bemutatása. Magyar Pszichológiai Szemle, 71(1), 25-56., https://doi.org/10.1556/0016.2016.71.1.2

[7] Marianna, S. C. (2019). Áthidalható-ea szakadék az oktatásban a digitális bennszülöttek és a digitális bevándorlók között?. Hulyák-Tomesz, T.(szerk.), 9-22.

[8] Balázs, B. (2020). Korszerű eszközök és módszerek a digitális nemzedék körében. Opus et Educatio, 7(1)., https://doi.org/10.3311/ope.368

[9] Molnár, G., & Pap, D. (2017). Generációk tanulása a digitális korban–Újgenerációs módszertani megközelítések és okoseszközök alkalmazása a tanítás-tanulás folyamatában., doi:10.13140/RG.2.2.33307.36641

[10] Molnár, G., & Orosz, B. (2019). Digitális eszközök használatával támogatott korszerű módszertani, tartalmi, technológiai megoldási lehetőségek a szakképzésben.

[11] Joanna ROSAK-SZYROCKA, Simona Andreea APOSTU, Bulent AKKAYA – Higher education and digitalization in perspective of use of internet, integration of digital technology, digital public services: panel study of EU nations, Scientific Papers of Silesian University of Technology – Organization and Management Series – Issue No. 181, DOI: http://dx.doi.org/10.29119/1641-3466.2023.18130

[12] https://gyartastrend.hu/cikk/szemelyre-szabott-implantatumok

[13] Martin, T., & Csaba, D. (2020). Fröccsöntő szerszám tervezése. Multidiszciplináris Tudományok, 10(2), 25-29., https://doi.org/10.35925/j.multi.2020.2.4

[14] Topa, M., & Dömötör, C. (2019). Fröccsöntő szerszám tervezése. MULTIDISZCIPLINÁRIS TUDOMÁNYOK: A MISKOLCI EGYETEM KÖZLEMÉNYE, 9(3), 44-56., https://doi.org/10.35925/j.multi.2019.3.4

[15] Kónya G, Kovács ZF. Effects of Machining Parameters and Tool Reconditioning on Cutting Force, Tool Wear, Surface Roughness and Burr Formation in Nickel-Based Alloy Milling. Materials. 2023; 16(22):7140., https://doi.org/10.3390/ma16227140

[16] Ficzere, P. (2022). Research on and Practice of Additive Manufacturing Technologies. Hungarian Journal of Industry and Chemistry, 49(2), 59–64. https://doi.org/10.33927/hjic-2021-23

[17] Dömötör, C. (2023). Reconstruction of Simple Parts Using FDM Technology. DESIGN OF MACHINES AND STRUCTURES: A PUBLICATION OF THE UNIVERSITY OF MISKOLC, 13(2), 13-21., https://doi.org/10.32972/dms.2023.013

[18] Kastratović, E., Dragić, M., & Arsenijević, O. (2022). Comparative analysis of the views of management students and managers on the importance of creativity for work. International Review, (3-4), 18-23., DOI: 10.5937/intrev2204017K

[19] Rosak-Szyrocka, J., Żywiołek, J., Zaborski, A., Chowdhury, S., & Hu, Y. C. (2022). Digitalization of higher education around the Globe during covid-19. Ieee Access, 10, 59782-59791., DOI: 10.1109/ACCESS.2022.3178711

[20] DÖMÖTÖR, C. (1785). Statistical analysis of natural analogy catalogue. Design of Machines and Structures, ISSN, 6892, 5-12., https://www.uni-miskolc.hu/dms/docs/dms_vol4_nr2_2014.pdf

[21] Takács, Á. (2017). Computer Aided Concept Building. In Solid State Phenomena (Vol. 261, pp. 402–407). Trans Tech Publications, Ltd. https://doi.org/10.4028/www.scientific.net/ssp.261.402

[22] Szántó, A., Kiss, J., Mankovits, T., & Szíki, G. Á. (2021). Dynamic Test Measurements and Simulation on a Series Wound DC Motor. Applied Sciences, 11(10), 4542., DOI: 10.3390/app11104542

[23] Rosak-Szyrocka, J., Żywiołek, J., Nayyar, A., & Naved, M. (Eds.). (2023). The Role of Sustainability and Artificial Intelligence in Education Improvement (1st ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781003425779

[24] Blaskova, M., Blasko, R., Matuska, E., & Rosak-Szyrocka, J. (2015). Development of key competences of university teachers and managers. Procedia-Social and Behavioral Sciences, 182, 187-196., DOI: 10.1016/j.sbspro.2015.04.755

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