Kateřina Petrová, PhD

Assistant Professor
Brno University of Technology, Czech Republic
Faculty of Business and Management
Email: xphornungova@vutbr.cz
Orcid: https://orcid.org/0000-0002-6895-1238

Jana Hornungová, PhD

Assistant Professor
Brno University of Technology, Czech Republic
Faculty of Business and Management
Email: Jana.Hornungova@vut.cz
Orcid: https://orcid.org/0000-0001-5788-4044

IMPLICATION OF COVID-19 ON DIGITAL EDUCATION: A SYSTEMATIC LITERATURE REVIEW

Abstract

The aim of this study is to assess the current state of digital education by identifying differences between blended and traditional learning models, examining the impact of the COVID-19 pandemic on digital education, and determining which multimedia and digital tools are used in the learning process. A systematic literature search was conducted using PRISMA guidelines, resulting in the selection of 50 open-access peer-reviewed articles published between 2007 and 2022. The studies were analyzed using MAXQDA software and synthesized into three thematic categories aligned with the research questions. Findings show that digital education is becoming an indispensable component of modern pedagogy, promoting interactive and intuitive learning experiences. Tools such as gamification, virtual reality, and multimedia platforms enhance student engagement, collaboration, and creativity. Nevertheless, challenges persist, including limited infrastructure and low digital literacy in under-resourced contexts. The study contributes to the field by offering practical insights and recommendations for educators, policymakers, and researchers striving to build inclusive and sustainable digital learning environments.

Keywords: digital education, digital learning, e-learning, Covid-19

1.   INTRODUCTION

The worldwide spread of the coronavirus has influenced many aspects of life. It has transformed society and accentuated the importance of digital education in everyday life. Existing learning trends have been tremendously modified, magnified, and shifted to online and hybrid learning. Due to the enforced closure of educational institutions, several students did not stay in touch with teachers, especially those from deprived surroundings. Due to their reliance on physical attendance and digital equipment in the schools, many fell behind the others. The rapid shift to remote learning led to the lack of digital infrastructure and caused educational gaps in less-developed countries. Students from different age groups have dropped out of the school system without the skills needed to find appropriate work. This vicious cycle will exacerbate the inequality between high-income and low-income countries. Whereas schools in rich countries were closed 53 days on average in 2020, in countries with limited digital infrastructure and fewer economic resources were closed on average 115 days (European Investment Bank, 2021). Given the correlation between education and performance, less developed countries with fewer skilled workforce will strive to catch up with more developed countries. As a result, the pandemic's effect causes a learning loss and will have a long-term consequence in the social and economic areas.

COVID-19 highlighted the need to unlock the potential of digital capacity, develop digital skills in education, and amplify the digital divide, especially between individuals with access to digital technologies and those from rural areas. Digital education has become a significant pillar of education. Digital transformation has become the main initiative in several training institutions dealing with digital capacities. These initiatives are mainly related to current initiatives, primarily Industry 4.0, Education 4.0, and Labour 4.0. During the pandemic, teachers have revealed more innovative ways of learning and coordinated efforts to provide online learning. Motivating students to perform better and supporting creative and critical thinking are aspects that develop skills. In the case of setting the conditions for completing the course, it is important to set the goals that need to be achieved. The digital learning model consists of different learning tools and digital education resources, ranging from online platforms and multimedia software, learning management systems through TV/radio-based teaching, to paper assignments physically taken home or distributed via email. A new type of learning environment with a new way of communication supports and promotes the development of digital education (Jiand & Xu, 2016).

Nevertheless, it is important to focus on the programs' quality and attractiveness and provide practical training for the needs of the labor market. The effectiveness of digital learning relies heavily on resources such as internet access, digital materials, digital devices, and particularly parental involvement for young children. Providing practical guidance on digital tools helps bridge social cohesion and eliminate educational gaps caused by the COVID-19 crisis. The effective use of remote learning helps to mediate a creative and quality educational system that can flexibly respond to the requirements of the labor market and increase the

qualifications of the workforce and is a necessary parameter to ensure the sustainability of the education system. Modern teaching methods include alternative education tools such as e-learning, gamification, simulation, and virtual reality, with the advantage of student engagement.

Although digital education has been widely studied, the existing literature is often fragmented and lacks a systematic synthesis connecting the differences between digital and traditional learning models, the specific impact of COVID-19 on the acceleration of digital transformation, and the deployment of multimedia tools in education. This study addresses this gap by providing a comprehensive and structured review of the literature between 2007 and 2022, using PRISMA methodology, and categorizing the findings into three key dimensions: (1) digital vs. traditional learning, (2) the effects of the COVID-19 pandemic, and (3) the application of multimedia tools. The novelty of this paper lies in integrating these three perspectives in a single systematic review, offering a holistic view of how digital education has evolved and what tools and practices are shaping its current and future direction.

2.   DIGITAL EDUCATION INFLUENCED BY COVID-19

The implementation of new ways of learning, such as digital education and e-learning, has become more popular since the outbreak of COVID-19. The digitalization of education is the main priority of a number of educational institutions in countries worldwide. The transition of traditional lecturing has radically changed the educational system and its meaning and purpose (Radchenko & Pevrukhina, 2020). Digital forms of education improve performance and support a collaborative and effective school environment (Vallé et al., 2020). Institutions providing education strive to restructure the educational system, and their attention is associated with more interactive forms of learning using digital technologies in all stages of the learning process – from the presentation of materials to the modeling and application of innovative teaching methods. Digital education allows a flexible manner of managing the distribution of knowledge; however, the relationship between student and teacher is more formal in comparison with the traditional form of lecture. The main challenge of online education concerns is keeping students' attention and motivated. Planning the course and using new approaches requires thorough preparation with respect to the nature of the student.

Digital education comprises a wide range of teaching and learning approaches based on using electronic media and devices such as training, communication, and interaction tools. These aspects may be related to educational approaches, concepts, methods, or technologies. Furthermore, these concepts have facilitated distance learning, which could help address the absence of students and reduce time and geographic barriers to training and education (e.g., rural areas) (Martinengo et al., 2019).

Researchers distinguish three types of digital education at universities (Wakefield et al., 2008):

1. blended learning,

2. distance learning,

3. mass open online courses.

Blended learning allows one to adapt to a changing environment in education. It integrates cutting-edge technologies into the learning process to provide a more effective teaching method in various disciplines. It involves the combination of face-to-face and distance learning and attempts to overcome a few limitations of the conventional form of education (Wakefield et al., 2008). Blended learning typically follows a 70:30 ratio of online and offline education using platforms, resources, and methods such as video conferencing, Broadcast, Physical classroom, virtual classroom, Web-based learning, simulations, recording, peer support, Documents, Computer-based and multimedia-based training (Wakefield et al., 2008).

Distance learning supports and focuses on the individuality of students, allowing conducting the educational process without the physical presence of a teacher. This form of lecture contributes to the development of independence and creativity skills.

Mass open online courses are based on the concept of 'lifelong education' and focus on self-education and professional development (Radchenko & Pervukhina, 2020).

Otherwise, the conventional classroom form of lectures is a face-to-face learning format, such as physical activities in the classroom and exercises that are nondigital and not mediated online. It has a long history and involves a physical classroom and the synchronous physical presence of teachers and students (Balle et al., 2018).

E-learning is a concept that transfers knowledge virtually without face-to-face interaction (Steinbuß et al., 2017). It is considered an 'environment in which the learner's interactions with learning materials (readings, assignments, exercises, etc.), peers, and/or instructors are mediated through advanced information technologies' (Alavi & Leidner, 2001).

Digital competencies have become more desirable due to constant technological progress. Lifelong education of digital competencies and skills is indispensable for each individual who encounters digital technologies. Since the outbreak of COVID-19, the importance of digital skills has increased due to the unprecedented use of technology for education, and rapid digitalization has become a strategic initiative in a number of organizations. Under the restrictions of COVID-19, many investments have been made in digital technology to integrate it into education and training systems (Digital Education Action Plan, 2022). Due to the unexpected shift to the remote workplace, schools and training centers moved to the emergency mode of distance learning using various channels. Digital learning

and digital technologies were deployed skillfully and effectively to support high-quality and inclusive education for students fully. The rapidly shifting environment of digital education and the mass use of technology revealed opportunities for teachers to provide their courses differently and interact with students on a more personalized basis, focusing on their specific needs. Even though digitalization over the decades has been the main initiative in European countries, the pandemic has revealed that the system has shortcomings and that the potential of digitizing education is not widely visible and understood. The extensive government restrictions that included school closures revealed the uneven and inconsistent technology-based education needed to provide distance education. The access to technologies in various countries has differed greatly (Dreesen et al., 2020). The lack of digital readiness was the primary barrier, and the vast majority of teachers had little experience with remote learning. Institutions that had invested in digital capacity before the coronavirus outbreak were better prepared to adapt learning approaches, and it has brought breakthrough progress in educational development. The crisis underscored the importance of digital education globally, and digital infrastructure is constantly popularizing.

Digital technologies facilitate flexible and student-centered learning in all phases of education and training. Digital education has replaced the conventional traditional teaching/learning approach during the coronavirus pandemic, and after the lockdown period, it has become a complement to the traditional format of education. The fundamental pillar of digital education, with the outstanding characteristics of a dynamic and interactive environment, is digital educational resources. Even though online learning is difficult to handle without face-to-face communication, online learning platforms increase the approaches to learning and collaborating by acquiring knowledge and integrating teaching videos and teaching materials (Facer & Selwyn, 2021; Nasiri et al., 2020). Multimedia materials can be incorporated into digital educational resources through digital technologies supported by multimedia computers or networks (Jiang & Xu, 2016). Teachers record their courses, and an unlimited number of students can watch them anytime (Yin, 2021). Online learning reduces the cost of learning and provides a flexible way of education for learners. Technology provides collaborative and creative learning in a fully online or blended mode environment.

In contrast to traditional classroom education, digital education stimulates students in innovation and supports voluntary and cooperative activities. The shift to an interactive education format supports students' participation – using gamification and virtual reality. Students are motivated and involved in the immersive virtual world. Students with disabilities often face challenges in accessing technological devices and require that technologies be inclusive of their needs. Cutting-edge tools can help overcome such barriers by providing innovative virtual or hybrid learning environments. The pandemic accelerated rapid digitalization and transformed many aspects of life.

Nevertheless, the balance of digital education and traditional learning is essential. Digital education has not replaced the standard education format but is a

complement. In addition, using digital tools and resources can create a collaborative environment for the new generation and improve learning efficiency in the digital age (Medina, 2022).

Digital or online education can be classified due to the extent of the course and the diversity of methods used. The term blended learning is a combination of online and face-to-face learning. Allen et al. (2007) determine a classification of course delivery methods presented in Table 1.

Table 1 Classification of different forms of education

Proportion of Online Content Delivered	Type of Course	Description
0%	Traditional	Course with no online technology used. The content is delivered in writing or orally.
1 – 29%	Web Facilitated	A course that uses web-based technology to facilitate what is essentially a face-to-face course. This type of course uses a course management system (CMS) or Web pages to post the syllabus and assignments.
30 – 79%	Blended/Hybrid	Course with a combination of online and face-to-face delivery. A substantial proportion of the content is delivered online; the typical method is online discussions and, as a rule, has some face-to-face meetings.
80 – 100%	Online	A course that is delivered primarily online. No face-to-face meetings.

Source: Allen et al. (2007)

The online course provides at least 80 percent of the content via online technology, whereas the blended/hybrid form of the course delivers the content between 30 – 79 percent online. It is a combination of online and face-to-face learning. Institutions have a number of options for structuring their activities, and they can mix the approaches to choose the best proportion. The proportion of 1 – 29 percent is classified as a web-facilitated course; the program uses web-based technology to facilitate what is essentially a face-to-face course. The traditional course type provides oral or written content without online technology.

3.   METHODOLOGY

Within the research of digital education, the following research questions are defined:

RQ1: How has the evolution trend in publications aimed at digital education developed over the last 15 years?

RQ2: What are the differences between the digital and traditional forms of education?

RQ3: What is the impact of COVID-19 on digital education?

RQ4: What multimedia and digital tools are used in the teaching and learning process?

This study involves a systematic review of the contents for analysis and synthesis within secondary research. The methodological scheme follows PRISMA guiding principles for systematic review and meta-analyses. Within the literature review, the code system is used for the categorization.
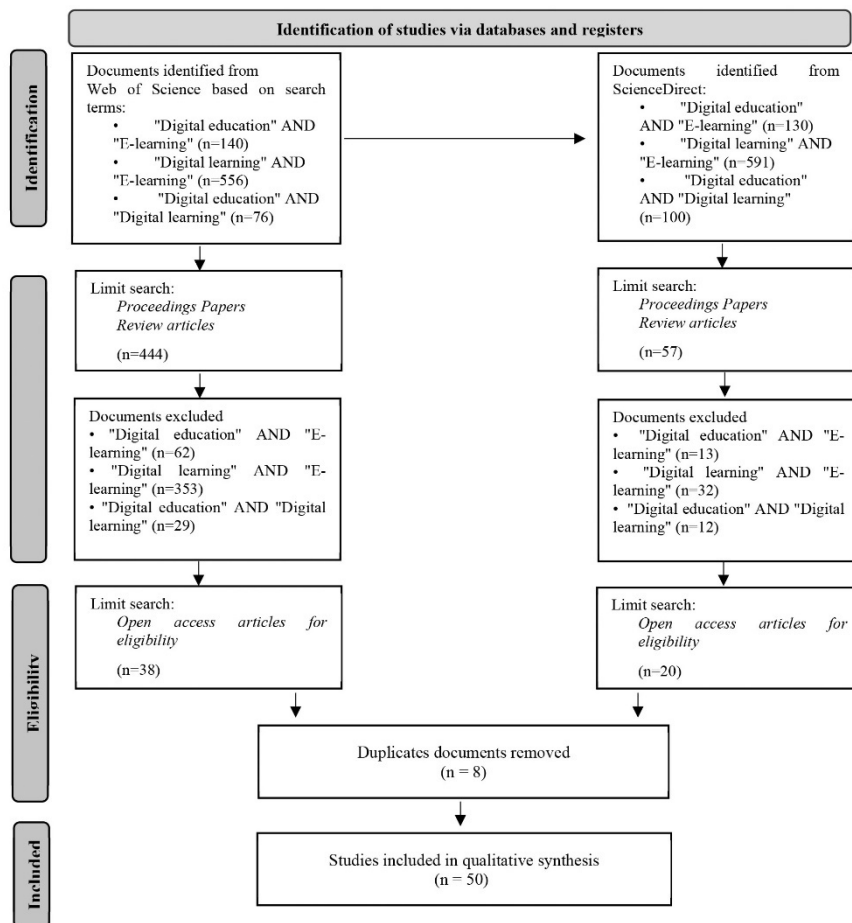

Figure 1 Flow scheme of literature review followed PRISMA guidelines

Source: Own processing based on PRISMA statement

Figure 1 shows the flow diagram that maps out the several numbers of documents identified, selected, and critically evaluated relevant research. The PRISMA four-phase flow diagram illustrates the selection process. The first phase, Identification, focuses on sources in search from two large multidisciplinary bibliographic databases, Web of Science and ScienceDirect, which cover the journal literature from different scientific fields, medical and social sciences

journals, including the humanities. No restrictions were applied for language, year, region, and subject area. The search was carried out using the search keywords "Digital Education," "E-learning," and "Digital learning" using Boolean operators AND between each term.

3.1.   Inclusion and exclusion criteria

The second phase, Screening, was refined by limiting the search due to the scope of the review and dataset. The search was limited to restricted types of documents, Proceedings papers, and Review articles. In addition, for the purpose of the study, Eligibility was applied to restrict Open access articles in the third phase. A total of eight duplications were found.

3.2.   Data collection and analysis

In the fourth phase, 50 articles for qualitative synthesis were shortlisted (McKenzie et al., 2021). Each study was reviewed, and the results were exported to the RIS format and imported into MAXQDA software. The search was conducted in April 2022. The manual abstracts control excluded 10 irrelevant studies, leading to a reduction to 50 relevant studies. A total of 162 authors have written articles from various scientific fields, such as Education and Educational Research, Behavioural Sciences, Business and Economics, Environmental Sciences and Ecology, Social Sciences, Computer Science, Mathematics, Remote Sensing, Telecommunications, etc. Fourteen articles are single-authored, and thirty-six- are multi-author collaborations. Analysis revealed that collaboration among authors is common. The collaboration index of authors across all multi-author publications is 4.05, which signifies an average number of co-authors per article. Each article was manually reviewed, and the information extracted from the review is the following: The type of multimedia tool used in digital education, the differences between conventional and digital education, and the impact of COVID-19 on digital education.

Graphical depiction of text using the Word cloud tool in MAXQDA displays key concepts and data in graphical form and identifies common themes of studies in the included analysis. The most represented words are learning, education, digital, learning, students, etc. This approach is suitable for initiating the coding of qualitative data. The idea of the most used terms helps to determine research questions (DePaolo & Wilkinson, 2014).

Figure 2 Word Cloud of Key Concepts Data within Qualitative Research

Source: Own processing

4.   RESULTS

The research was conducted by electronic searches for eligible studies through two international databases, Web of Science (the abbreviation WoS will be used further in the text) and ScienceDirect. Both databases are online scientific information services that provide research studies due to the fact that WoS has a greater number of indexed journals compared to ScienceDirect; a greater number of indexed articles were published in WoS in this subject of analysis (Sánchez et al., 2017). This initial search retrieved 1,593 studies. Following the PRISMA guidelines, 50 potentially eligible studies were selected (36 studies in WOS and 14 studies in ScienceDirect). Figure 3 presents the number of published articles related to the year of publication. The first study appeared in 2007 and was indexed in the WOS database. In total, four studies were published in 2022. The algorithm showed that the most productive years were 2020 and 2019 in the WOS and 2022 and 2020 in ScienceDirect. Table 2 provides an overview of the research trend of digital education. The selection of relevant literature was subjected to a systematic review that included examination and extracting information as itemized below. The research is divided into three categories related to research questions: Blended digital learning versus traditional learning, the impact of COVID-19 on digital education, and the type of multimedia and digital tools used in the teaching and learning process. The explanation of each category is provided below.

Table 2 Overview of research trend in digital education

Research question/coding	Subcategory	Number of studies	Categories/Focus
RQ2: What are the differences between blended digital learning and traditional forms of learning?	General overview	12	Digital educational platform sustainable for displaced children Connectivism leadership Advantages of online education Differences between blended learning and conventional classroom Factors Influencing Blended Learning
	The potential of digital education in health disciplines	5	The effectiveness of digital education in comparison to traditional learning
	Development of digital skills	4	The exponential increase in the development of digital skills The digital initiatives for supporting the development of digital skills
RQ3: What is the impact of COVID-19 on digital education?	Educational System's Continuity and sustainability in the COVID pandemic	6	A sustainable system of digital education
	E-learning Challenges	6	Formats of e-learning Benefits and drawbacks of the e-learning system concept Factors determining the successful adoption of e-learning
	Criteria of Digital Competencies	1	Descriptors of key competencies in the digital economy
RQ4: Which multimedia and digital tools are used in the teaching and learning process?	Learning Management System (LMS)	6	LMS as a learning environment Criteria of Success in Learning Management System (LMS)
	E-learning	6	Challenges of e-learning
	Digital educational tools	4	Mobile devices and apps as a learning approach Multimedia educational tools enhance the digital learning environment

Source: Own processing

RQ1-RQ4 uses a coding system in MAXQDA software to address research questions and categorize studies by unique characteristics. In the

conception of the coding categories, emphasis is put on the different dimensions aligned to the broad analysis of the types of studies in the point of our interest. Research question 1 focuses on the distribution of publications according to the researched theme. Research Question 2 relates to the studies reflecting the differences between digital and traditional forms of education. Research Question 3 assesses the impact of COVID-19 on digital education. Research Question 4 captures studies on multimedia and digital tools used in teaching and learning.

RQ1 is plotted in the following Figure 3 to answer the research question based on bibliographic data from MAXQDA. It presents the number of articles related to the search terms digital education, digital learning, and e-learning. The first publication was published in 2007. As can be seen, the highest number was observed in 2020, with 25% (10 publications) of total publications. Furthermore, the increasing trend of journal publications has doubled. The slight exception occurred in 2021.
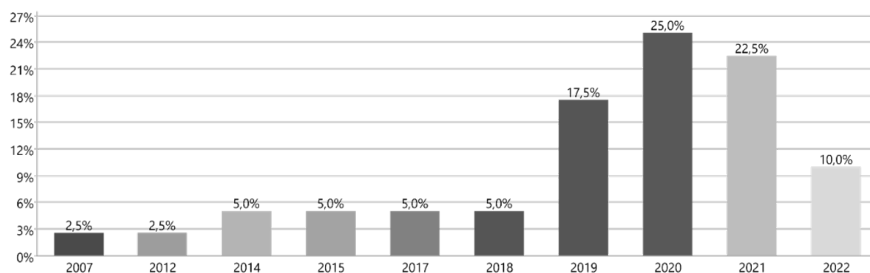

Figure 3 The number of articles related to digital education, digital learning, and e-learning during the period 2007 - 2022

Source: Own processing

Based on several studies, three thematic categories are created (Blended digital learning vs. traditional learning, Impact of the COVID-19 pandemic on digital education, and Media tools used in digital education) with subcategories based on the nature of analyzed studies. Among the 50 identified articles, 14 studies were classified under the theory of blended digital learning versus traditional learning. Furthermore, 11 studies identified the impact of the COVID-19 pandemic on digital education. The remaining studies were organized into the Multimedia tools used in the category of digital education.

4.1.   Blended digital learning vs. traditional learning

Regarding the research, question 2 is mapped out in 21 studies. The analysis comparing digital learning versus traditional learning comprises the sample, which is broken down into categories: i) general overview, ii) the potential

of digital education in health disciplines, and iii) the development of digital skills. All categories are dynamic and should be seen as interconnected. In the following section, three categories will be presented. The general overview will discuss the importance of digital learning in online space.

i) General overview (12 studies) - The conventional form of learning required a reinvigoration of teaching. Digital technologies in education promote more autonomous, self-directed, and engaging learning, as most of the learning is initiated by students. Almasri et al. (2018) focus in their study on the digital education platform that will be sustainable in terms of the Syrian war and allow distance education to displaced children. The authors suggest that the four pillars of the platform that can assure digital education are hardware, software, curriculum, and support services. They design considerations to provide recommendations for the four pillars of the platform. The three aspects of consideration are supervised self-directed learning methods, context-aware education, and kid-oriented design. These considerations are essential for the pillars. Corbett and Spinello (2020) present the study of the theory of connectivism on a theoretical level. The principles of connectivism were introduced in 2004 and are anchored in the digital age. Connectivism has implications for all aspects of life, including management and leadership. In summary, Connectivist leadership has redefined the paradigm in recent years. It is considered a dynamic, connected, and collective influence process based on principles of digital knowledge and interpersonal neural networks. From the perspective of this theory, it has the potential to be seen as a core competency of effective leadership in the recent century. Versteijlen et al. (2017) examine the arguments for the pros and cons of online education according to the production of carbon emissions in higher education in the Netherlands. The results prove that online education reduces the carbon impact of students and staff travel. A series of interviews with online education reveals that the advantages of online education are predominantly flexibility, the power to personalize the educational needs of individuals, and the possibility to extend the learning environment with digital tools. As a con of online education, authors indicate the noncommittal behavior of students. Another study that deals with blended learning in higher education is the contribution of Müller and Mildenberger (2021), who examine the overall differences between blended learning and conventional classroom learning through meta-analysis. The results show that blended learning with reduced classroom time is not systematically more or less effective than conventional learning. This finding shows that the learning format for learning success is not decisive, but the learning is strongly circumstantial and context-dependent. They point out that the efficiency of blended learning is often cited as a key argument and driver; however, there are relatively few analyses of the cost-efficiency of blended learning. Stevens et al. (2021) show that online education is associated with better outcomes than face-to-face education. Georgsen and Lovstad (2014) look at the most important factors for successfully using blended learning in the workplace. Using a combination of research methods, they concluded that workplace learning requires a suitable balance between learning and work. A national network of inspectors supported

the user-friendly virtual learning environment. The study by Chen et al. (2020) conducts a comprehensive systematic review of the importance of Artificial Intelligence in Education (AIEd). They evaluate that the interest in AIEd is continuously increasing, and there is a trend towards emotion detection in game-based learning through machine learning (ML) techniques of Ninaus et al. (2019) and NLP techniques. Radchenko and Pervukhina (2020) discuss the issues of methods of teaching a foreign language using digital tools. They focus on the features of an important didactic property of digital education, such as interactivity, which allows active participation in the learning process. Interactivity is divided into cognitive (student-educational material) and social (student-student). They noted that the association of augmented reality (AR) and gamification tremendously impacts higher education students in the digital educational process. The drawbacks of digitalization, such as the absence of human presence, can be annihilated by project work that has evident advantages for networking and teambuilding. Seow et al. (2022) conclude that the blended learning model will likely remain in a post-COVID era. Bouarab-Dahmani and Tahi (2015) refer to a comprehensive network with a distant tutor represented by an e-learning platform. Martinengo et al. (2019) declare that digital learning programs in health care are at least as effective as traditional learning in improving learner outcomes based on evidence from systematic reviews.

ii) The potential of digital education in health disciplines (5 studies) – central to this category is the assessment of the effectiveness of blended learning compared to traditional learning in health disciplines. The widening gap between innovations in the medical field may influence the quality of care provided. Three studies refer to digital education, especially in the health discipline. Studies point to the increasing potential of digital technologies in the training of medical doctors. George et al. (2019) evaluate the effectiveness of the combination of digital education and traditional learning and state that this combination is equivalent and possibly superior to traditional learning for training practicing medicals. This combination significantly improves learning outcomes compared to traditional learning. Vallée et al. (2020) demonstrate in their study that blended learning has a consistently positive impact on medical knowledge outcomes compared to traditional learning. Blended learning could be promising and worthwhile for further education. All studies performed a systematic review of blended learning in health education. Wahabi et al. (2019) focus their research on evaluating offline computer-based digital education compared to face-to-face learning. The crucial factors in the evaluation are costs and effectiveness. The results show that the effect of computer-based digital education on patient outcomes is negligible. Gentry et al. (2019) evaluated the effectiveness of gamification elements during health education. Based on the systematic literature review, they stated there is a small-to-large magnitude effect to improve skills and knowledge compared to traditional learning. The gamification element has at least the same effect on outcomes as other digital education modalities. Finally, Kyaw et al. (2019) assessed the effectiveness of digital education on medical students' communication skills compared to traditional education. The results reveal that blended digital education

is at least as effective as or more effective than traditional learning for communication and skills.

iii) Development of digital skills (4 studies) - The exponential increase in the need for digital skills relates to the transition to online space. It is a crucial factor in an entirely digital society. Developing skills, competencies, and capabilities to retrieve data and information should be central to digital competency development (Lameras & Moumoutzis, 2021). Searching online, using email or instant messaging, and the ability to use work-related online platforms should be included with generic competencies. The acceleration of digital transformation intertwines in every industry. The development of skills is necessary for employees' digital literacy. Digital initiatives are prioritized as the degree of more advanced digital skills necessary to propel digital transformation. According to the study of Dille and Røkenes (2021), internal factors are the core of the professional development of teachers in online communities. The main factors are the 'fear of losing face' and the 'technological fear,' which determine the participants' attitudes. The prerequisite for professional skills development is participants' willingness to self-study technologies and technological aspects. Low technological knowledge can be a crucial barrier to contribution to online programs. Luck et al. (2012) point to limitations in the digital learning process on the Internet and individualism vs. collectivism of learning. There is a strong relationship between personal content providing and consultancy and home-based learning without face-to-face consultancy. The achievement of learning experiences with the combination of experiential learning-based and team-based assignments can be more useful as individual learning. Lameras and Moumoutzis (2021) determine the important aspect of keeping abreast with digital competency development, learning about current trends in digital teaching through online searching relevant information. As a critical digital skill, they indicate 'Selecting and learning how to use a system focused on storing, using and sharing information and learning materials. The protection of sensitive personal information demands the need for a secure environment to let participants access and share information. The essence of digital media is understanding the literate media in terms of how particular media should be used to achieve learning dexterities. Several studies aim to increase the acceptance of technology by helping teachers understand the specifics of platforms, devices, and tools used in educational settings, thus building their confidence and ICT proficiency.

4.2.   Impact of pandemic COVID-19 on digital education

Other findings regarding research question 3, "What is the impact of COVID-19 on digital education?' highlight the importance of digital education in the pandemic era. Thirteen studies are categorized into three areas: i) Educational System's Continuity and Sustainability in the Coronavirus Pandemic, ii) E-learning Challenges, and iii) Criteria of Digital Competencies.

   i) Continuity and sustainability in the coronavirus pandemic (6 studies) – this field focuses on the sustainability of digital education following the unprecedented shift of the COVID-19 pandemic. The global spread of coronavirus has led to the opportunity to advance the use of digital technologies in a wide range. This transition to a more digital path requires more thoughtful guidance for a successful and sustainable digital education system. Luong and Arnold (2020) propose four key considerations to make a thriving digital learning community. The first consideration leads to an equitable distribution of technological resources among students from rural areas with a low socioeconomic population. Equal access to digital media mediates learning for all students without any difference. Sustainable education can be guaranteed to students on the state and city levels of the learning system. The second consideration deals with the influence of racism and values, and the third consideration focuses on sustaining learning and ultimately considers the digital learning community as a system. These considerations create a sustainable digital education that is safe, conducive to learning, and culturally responsive. Furthermore, Maqsood et al. (2021) sum up considerations of the post-pandemic situation and reveal areas that have struggled hugely due to the unprecedented shift to the potential of digital technology. They point out the importance of learning and teaching assessment using a learning management system to provide an online course review. To ensure sustainable education, it is necessary to embrace national policies for higher education linking with universities worldwide. Seow et al. (2022) mention the effect of the pandemic on surgical education and highlight the potential and challenges of the virtual format in surgical education. They determine crucial factors influencing digital education: strategy and resources for sustainability, optimal model choice for effective learning, and surgical skills acquisition. Besides that, they see the vast potential of virtual technology, such as proprietary and open-platform software and hardware used for teaching, mentoring, providing feedback, and assessments of teachers and students. Rahayu et al. (2022) pointed out that the most popular data types are feedback, assessment, and context data (e.g., emotional, cognitive, and cultural data). Zitzmann et al. (2020) highlight that objective and exact digital evaluation helps improve students' visualization, provides immediate feedback, and improves instructor and student self-evaluation. However, teachers and educators will have to face several challenges, such as sustainability and costs, variations in delivery models, and the applicability of surgical skills training. However, the sustainability of digital education requires a thoughtful strategy and resources in the long term. Regular content creation and curriculum screening need to be revised. Jones et al. (2022) highlight a benefit of Virtual infection prevention and control (VIPC), which allows coordination between professionals to combat infectious diseases effectively and helps to increase access to higher-quality healthcare. The VIPC platform can be helpful in less-developed countries. The research of Philippe et al. (2020) mentions the phenomenon of multimodality, which influences digital education, especially in highly interactive and immersive environments such as virtual reality. The concept of adaptive and deep learning lets us adjust the course to a more personalized form.

ii) Challenges in e-learning (6 studies) - The e-learning system has increased its potential since COVID-19. According to the study of Soellner (2021), every third company has conducted employee training via this platform. The author determines various formats of e-learning based on his systematic literature review: computer-based training, web-based training, game-based learning, serious games, microcontent, mobile content, simulations, business games, augmented reality, mixed reality, virtual reality, and learning videos. Zitzman et al. (2020) determine a helpful format for e-learning: educational videos, webinars, illustrating clinical exams or therapeutic steps, interactive systems, adaptive systems, and collaborative tools. Reviewed studies highlight several benefits of the concept of an e-learning system and point out factors determining the successful acceptance and adoption of an e-learning system. Furthermore, Awan et al. (2021) conclude that e-learning is the future of higher education institutions. Using this technology is beneficial for all stakeholders. This technology saves resources and time and supports creativity. Students benefit from time flexibility and more access to information. Modern methods such as user-friendly e-learning installed at the institution help save time for people who cannot physically attend the course and maintain information and knowledge. The authors mention the drawbacks in less developed countries, such as low internet bandwidth, lack of hardware resources, nonavailability of the Internet, or low computer literacy rate. Khan (2021) examines the pandemic's effects on e-learning changes. He highlights change management challenges such as e-learning system technical issues, financial assistance issues, technology factors, e-learning quality system factors, cultural factors, self-efficiency elements, and trust factors are among those emphasized. The migration from traditional learning to online learning increases the disruption in teaching. To avoid this disruption, it is recommended to provide training in digital literacy and the use of online flipped classrooms, encourage students to use peer-to-peer learning, and build community collaborations. Maqsood et al. (2021) focus on e-learning in the context of technological innovation, especially in well-developed countries. In these countries, they face unexpected barriers and transform them into opportunities that develop effective systems for satisfying the needs of teachers and students. The drawbacks mentioned and observed are the nondisciplined lifestyle and the lack of focus during education in e-learning. It can cause demotivation of the number of students who generally multitask whereas making a phone call. A key issue for sustaining an educational system is how to keep students' attention and interest in interactive teaching. In addition, there are challenges related to government principles and regulations needed to define online learning policies. Zitzman et al. (2020) address the necessity of changing the mindset of the dental faculty and providing training with e-learning to enable the transfer of theoretical and practical knowledge. COVID-19 has influenced the form of education, and there is a need for an alternative channel of education. Structural webinars can provide theoretical learning.

iii) Criteria for digital competencies (1 study) – According to the study by Chorosova et al. (2020), they identified and assessed and, moreover, investigated the classification of digital competencies. In the next stage, they identified

descriptors of key competencies in the digital economy. The criteria were divided into leading indicators to assess the results and a scale for assessing the level of competency formation. According to the assessing results, the authors proposed the competency matrices for all stages of competency formation. Moreover, the toolbox for identifying and evaluating the level of key competencies in the digital environment was designed to determine the needs of teachers.

4.3.   Media tools used in digital education

This chapter highlights the various multimedia tools used in digital education. Categorization: LMS, e-learning, digital educational tools. To find out the results related to the last research question, 16 studies were included and thoroughly analyzed. The most commonly applied media tools are LMS, discussed in 16 studies, and the e-learning platform, which was reported as the most used media tool in 20 studies, and furthermore, based on characteristics of digital tools that enhance the digital learning environment, Quizlet, Learning Apps, and Wiser.me, WordShift were identified.

i) Learning Management System (6) - The research of Georgsen and Lovstad (2014) supports the approach of Learning Management System (LMS), which allows the distribution of information, teaching schedules, and materials, assignments. Lameras and Moumoutzis (2021) promote digital inclusion using LMS as a learning environment. For this purpose, teachers should have knowledge and expertise in designing learning permeated in LMS. Luck et al. (2012) deal with the success of LMS, which enhances regional collaborative creative and literary writers' digital learning. At every state level, LMS portal administrators and instructors must be trained, skillful, dynamic, and experienced. This learning process will influence writers to gain various kinds of knowledge needed for advancing creative and literary societies and livelihood. Radchenko and Pervukhina (2020) focus on creating an information and educational environment at the university and interactivity as a feature of the didactic property of digital learning. The University uses digital platforms, such as the SKIF portal, as a digital medium for distance learning. SKIF represents a learning environment implemented based on the open-source software Moodle. Lopukhova et al. (2019) recommend using LMS to optimize the whole learning process. Saint et al. (2022) discuss LMS that can generate digital trace data, promising unobtrusive and authentic capture of learner behaviors. This can bring greater authenticity.

ii) E-learning (6) - Awan et al. (2019) refer to the e-learning platform as a relevant media tool to encourage collaboration that enables user-generated content and input. El Nabahany et al. (2019) demonstrate the e-learning project approach in their study and present SUZA MOODLE, a learning management system at the State University of Zanzibar that supports conventional classroom education by accessing a wide range of educational material. Gorbunovs (2021) used eye-tracking technology as a significant instrument to examine student learning needs, learning experiences, and activity peculiarities. Lakkala et al. (2007) investigated

the challenges of virtual inquiry practices through virtual collaboration using a web-based learning environment. Web-based learning is considered a coordination tool for organizing collaborative work. Lopukhova et al. (2019) focus on e-learning as a particular aspect of internationalization within the Russian higher education system. It has been proven that e-learning is an effective teaching/learning method with more diverse subjects.

Otherwise, Cukurova et al. (2017) focus on learning analytics to analyze collaborative problem-solving in traditional learning. Empirical research used a TALKOO physical computing kit, a novel prototyping approach with physical computing components. It comprises hardware modules, a visual IDE, and prototyping material.

iii) Digital educational tools (4) - In the contribution of Mills (2015), there is a focus on mobile devices as a learning approach for undergraduates within a Geomatics teaching environment. Mobile devices play an active role in teaching photogrammetry and remote sensing. He looked at apps that help students access teaching materials and engage in learning and teaching environments. The Newcastle University app plays a central role in students' lives; they can access the schedule, exam schedule, printing credit, campus map, etc. The Responseware app allows students to participate in lectures interactively by answering questions presented during the lessons. Geoviewer views raster and vector imagery in remote sensing. 123 catch helps the student to create 3D modeling using mobile devices to animate photogrammetry. Remote RDP takes control of the P20 laser scanner through mobile devices. The article by Perevalova et al. (2020) discusses the main pros of using digital educational tools that enhance digital learning environments, such as Quizlet, Learning Apps, Wiser.me, and WordShift. These apps allow students to obtain the professional vocabulary necessary to read and analyze scientific articles and obtain translation, reading, and analytical skills. The research indicates that mining engineering students need more effective approaches to learning, and integrating e-learning and web services increases overall satisfaction with ESP studies. Soellner (2021), within the study, deals with ERP systems that can be used to develop interactive and simulated environments available to learners. ERP systems can store learning materials, be adapted to students' individual needs, and be used in virtual classrooms. SAP S/4HANA is supposed to become the industry standard by 2027. Suzuki et al. (2014) developed a learning-material display created in ePub to support expressive power, decision-making, and thinking skills for high school and junior high school students. Subsequently, they created a database of learning records or the Internet search history by cooperating with the browser. Action research by Carvalho (2019) based on years of observation reveals that creating an e-portfolio is positively perceived, and student engagement has increased. The traditional assessment method was changed to an e-portfolio, which enabled multimodal digital literacy, crucial for preparing students to cope with the technologically advanced world. A study by Abdulrahaman et al. (2020) categorized multimedia tools as web-based and standalone. Standalone tools included computer representation, augmented reality,

computer-aided design, word-processing and presentation, presentation, 3D modeling and printing, video scribe and MS PowerPoint with I-spring, object-oriented programming, Camtasia Studio 7 program, E-book system. Web-based technologies are HTML 5, JavaScript and Cascading Style Sheet, LabView, CSS, computer representation, YouTube, and Macromedia. The systematic review of an ontology-based recommender system by Rahayu et al. (2022) identified ITS, LMS, CAI, and PLE as the most popular learning technology platforms.

5.　　DISCUSSION

The purpose of the study was to provide a systematic review of scientific literature dealing with terms of digital education, digital learning, and e-learning, touching upon the period 2007 – 2022 with a limit of peer-reviewed articles and proceeding papers. Related to the aim, the following research questions were formulated:

RQ1: What has the evolution trend in publications aimed at digital education been in the last 15 years?

RQ2: What are the differences between the digital and traditional forms of education?

RQ3: What is the impact of COVID-19 on digital education?

RQ4: What multimedia tools are used in teaching and learning?

In response to the coronavirus pandemic, the importance of digital education has increased, and traditional learning registered an immediate shift to digital learning that requires digital technologies and competencies. The study touches upon the complex overview of information, including various digital elements that can enrich lectures, teachers, students, and researchers. The main pros of digital education compared to traditional forms of education are flexibility, effectiveness, saving resources and time, creativity, critical thinking, better outcomes, and the high potential of virtual technology. Whereas the findings show that the association of augmented reality (AR) and gamification is having a tremendous impact on higher education students, the systematic review also revealed the disadvantages of digital education, especially in less developed countries with low internet bandwidth, no hardware equipment, low computer literacy rate, financial assistance issues, and cultural factors. In the context of digital education, there are drawbacks, such as the lack of human presence, evidence that project work, a nondisciplined lifestyle, and a lack of attention during digital education can annihilate its effectiveness. These factors can lead to the demotivation of students. The authors emphasize the importance of mentoring, exact digital assessment, and the provision of student feedback that can be mediated via a Learning management system. The authors sum up that the model of at least blended learning remains in a post-COVID period and is popularized. Combining digital elements and traditional learning can be a promising and worthwhile form of education. It can have a positive impact on knowledge outcomes of students'

comparison with traditional learning. A key concern persists in how to keep students' attention and interest through interactive learning.

Furthermore, the crucial finding is that regardless of the transition to online education, there is an exponential increase in the need for digital skills, competencies, and capabilities to avoid disrupting the transition from the conventional learning method to online learning. Therefore, the development of digital skills is prioritized within digital initiatives. A sustainable digital educational system is a challenge that requires a long-term, well-thought out strategies and resources and equal access to digital media for all students, making changes in national policies linking with institutions and all levels of the learning system taking into account the safety, effectiveness of learning, and cultural responsibility. According to studies, the potential of e-learning systems that include many useful features has increased due to the pandemic era. E-learning allows for the management, planning, and delivery of education in many diverse settings and can be an effective tool for distributing knowledge. Further findings in the framework of a systematic review are that companies carr out employee training in various formats: computer-based training, web-based training, game-based learning, serious games, educational videos, webinars, microcontent, mobile content, simulations, business games, augmented reality, adaptive systems, mixed reality, virtual reality, and learning videos. Simulations, virtual reality, and augmented reality engage students in more practice-oriented activities that foster peer-to-peer learning and interactivity – in the context of research question four, various multimedia tools used in digital education. Multimedia tools that stand alone are organized computer representation, augmented reality, computer-aided design, word processing and presentation, 3D modeling and printing, video scribe and MS PowerPoint with I-spring, Object-oriented Programming, Camtasia Studio 7 program, and E-book system. The web-based learning environment is considered a coordination tool for organizing collaborative work.

Authors referred to web-based platforms HTML 5, JavaScript, Cascading Style Sheet, LabView, CSS, computer representation, YouTube, and Macromedia. The most popular learning platforms are ITS learning, LMS, CAI (Computer-assisted instruction), and PLE (Personal learning environment). The authors sum up that the most applied media tool was the learning environment LMS, which supports collaboration and creativity during education. Consequently, digital educational tools that enhance digital learning are Quizlet, Learning Apps, and Wiser.me, WordShift. In particular, because traditional learning is expected to include elements of digital education more frequently, it is necessary to confront students with digital tools already at an early stage of their education. Identified digital multimedia tools can help overcome digital challenges and engage students in education outside the classroom.

As the use of multimedia tools and platforms continues to evolve, recent research further expands the understanding of digital education in emerging contexts. Although this systematic review focused on literature published between 2007 and 2022, recent studies continue to explore the evolving landscape of digital

education. For instance, AL-Smadi (2023) examines the transformative role of generative AI models like ChatGPT in educational contexts, highlighting both opportunities and challenges. Similarly, Thahir et al. (2023) discuss the implementation of blended learning approaches in higher education during the post-pandemic era, emphasizing the integration of technology with traditional teaching methods. These studies underscore the dynamic nature of digital education and suggest avenues for future research.

6.   CONCLUSION

This article conducts a systematic review of relevant scientific literature that identifies the role of the digital education paradigm in the teaching and learning processes amplified by the COVID-19 pandemic. The initial search was carried out according to the PRISMA guidelines. There were limitations in the systematic search. The results were restricted to English articles and open-source documents. The results cover the period 2007–2022. The systematic review was intentionally limited to publications from 2007 to 2022 to ensure a comprehensive analysis of peer-reviewed, indexed, and open-access sources within a defined timeframe. Literature published after this period may be considered in follow-up studies to capture emerging trends and developments. Taking into account the inclusion criteria and manually checking the relevance of abstracts, a total of 50 articles were selected for further analysis via MAXQDA Analytics Pro 2020.

The results of the synthesis show recurring themes across the literature. Studies emphasized that digital education has the potential to evolve into a sustainable system of teaching and learning. A key finding is the role of digital tools in fostering student engagement, creativity, collaboration, and critical thinking. Technologies such as gamification, augmented reality, and virtual reality were frequently highlighted for their capacity to support immersive learning experiences. Rather than being descriptive accounts, the studies collectively indicate a trend toward the increasing adoption of interactive, student-centered learning approaches. However, significant challenges remain, particularly in less developed countries, where limitations such as low digital infrastructure, insufficient hardware, and inadequate digital literacy persist.

Another common thread in the reviewed studies is the urgent need to develop digital competencies. This is particularly relevant as the labor market increasingly demands digitally skilled professionals. A synthesis of findings suggests that the transition to digital education must be accompanied by policy-level support and institutional strategies to build digital capacity.

Therefore, researchers should pay attention to which media tools, digital elements, and principles are most effective and how to conduct courses in the digital path successfully. Integrating game-based learning in curricula provides a number of challenges. Monitoring trends enriching traditional education can be a proposal for further research in the educational area. Regardless of circumstances,

measuring digital education's impact on student's participation in the learning process can bring important data and infer results of the effectiveness of digital elements. This study demonstrates that digital education is an indispensable part of learning and revolutionizes daily practice. It has great potential in various areas and provides more interactive and intuitive possibilities for education.

From a practical standpoint, these findings suggest the need for educators and policymakers to invest in digital infrastructure, enhance teacher training for online delivery, and promote inclusive access to technology. Future research should explore the longitudinal effects of digital learning on educational outcomes and equity, especially in underserved populations. Additionally, the effectiveness of various multimedia tools and blended models in different disciplinary and cultural contexts remains an area worthy of deeper investigation. These findings are in line with recent discussions in Economic Thought and Practice, which highlight the role of digital learning environments and leadership in navigating educational innovation (Zeqiri, 2021; Živković, 2022). These recent contributions underscore the dynamic nature of digital education and suggest avenues for future research.

To conclude, this study offers several main contributions: it provides a unique synthesis of research on digital education from multiple perspectives – pedagogical models, pandemic influence, and technology integration. It highlights the transformative potential of digital tools, especially in enhancing student engagement, creativity, and interactivity. However, limitations include the exclusion of non-English sources, the dependence on open-access publications, and the exclusion of the SCOPUS database, one of the most significant multidisciplinary sources often used in systematic reviews. SCOPUS was not included due to access restrictions during the research, which may affect the findings' comprehensiveness.

Future research should build on this review by conducting empirical studies to test the impact of specific tools and pedagogical approaches. Educators are encouraged to integrate evidence-based digital practices into their curricula; policymakers should support investments in equitable digital infrastructure; and researchers should continue exploring inclusive, effective, and sustainable digital learning environments.

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REFERENCES

Abdulrahaman, M. D., Faruk, N., Oloyede, A. A., Surajudeen-Bakinde, N. T., Olawoyin, L. A., Mejabi, O. V., Imam-Fulani, Y. O., Fahm, A. O., & Azeez, A. L. (2020). Multimedia tools in the teaching and learning processes: A systematic review. *Heliyon*, *6* (11), 1-14. https://doi.org/10.1016/j.heliyon.2020.e05312

Alavi, M., & Leidner, D. E. (2001). Research commentary: Technology-mediated learning – a call for greater depth and breadth of research. *Information Systems Research*, *12* (1), 1-10. https://doi.org/10.1287/isre.12.1.1.9720

Allen, I. E., Seaman, J., & Garrett, R. (2007). *Blending in: The extent and promise of blended education in the United States*. Sloan Consortium.

Almasri, N., Tahat, L., & Terkawai, L. A. (2018). How can technology support education in War – WarAware education platform for Syria. In Al-Sharhan, S. et al., *Challenges and Opportunities in the Digital Era* (Lecture Notes in Computer Science, vol. 11195), 436-448. https://doi.org/10.1007/978-3-030-02131-3_39

AL-Smadi, M. (2023). ChatGPT and Beyond: The Generative AI revolution in education. *arXiv*. https://ar5iv.org/abs/2311.15198

Awan, R. K., Afshan, G., & Memon, A. B. (2021). Adoption of e-learning at Higher Education Institutions: A systematic literature review. *Multidisciplinary Journal for Education, Social and Technological Sciences*, *8* (2), 74-91. https://doi.org/10.4995/muse.2021.15813

Balle, S., Petersen, A., & Nortvig, A. (2018). A Literature Review of the Factors Influencing E-Learning and Blended Learning in Relation to Learning Outcome, Student Satisfaction and Engagement. *Electronic Journal of e-Learning*, *16* (1), 46-55.

Bouarab-Dahmani, F., & Tahi, R. (2015). New Horizons on education inspired by information and Communication Technologies. *Procedia – Social and Behavioral Sciences*, 174, 602-608. https://doi.org/10.1016/j.sbspro.2015.01.589

Carvalho, A. A. (2019). Using mobile devices and online tools to promote students' learning. In *Sustainable ICT, Education and Learning. IFIP Advances in Information and Communication Technology*, 564, 7-15. https://doi.org/10.1007/978-3-030-28764-1_2

Chen, X., Xie, H., Zou, D., & Hwang, G.-J. (2020). Application and theory gaps during the rise of Artificial Intelligence in Education. *Computers and Education: Artificial Intelligence*, 1, 1-20. https://doi.org/10.1016/j.caeai.2020.100002

Chorosova, O. M., Aetdinova, R. R., Solomonova, G. S., & Gerasimova, R. E. (2020). Spring 2020: Toward a digital transformation of Education. In *VI International Forum on Teacher Education, Kazan Federal University*, Russia. ARPHA Proceedings 3, 381-393. https://doi.org/10.3897/ap.2.e0381

Corbett, F., & Spinello, E. (2020). Connectivism and leadership: Harnessing a learning theory for the digital age to redefine leadership in the twenty-first century. *Heliyon*, *6* (1), 1-9. https://doi.org/10.1016/j.heliyon.2020.e03250

Cukurova, M., Luckin, R., Mavrikis, M., & Millán, E. (2017). Machine and human observable differences in groups' collaborative problem-solving behaviours. In *Data Driven Approaches in Digital Education*, 10474, 17-29. https://doi.org/10.1007/978-3-319-66610-5_2

DePaolo, C. A., & Wilkinson, K. (2014). Get your head into the clouds: Using word clouds for analyzing qualitative assessment data. *TechTrends*, *58* (3), 38-44. https://doi.org/10.1007/s11528-014-0750-9

Digital Education Action Plan (2021-2027). *European Education Area*. (n. d.). https://education.ec.europa.eu/focus-topics/digital-education/digital-education-action-plan

Dille, K. B., & Røkenes, F. M. (2021). Teachers' professional development in formal online communities: A scoping review. *Teaching and Teacher Education*, 105, 1-17. https://doi.org/10.1016/j.tate.2021.103431

Dreesen, T., Akseer, S., Brossard, M., Dewan, P., Giraldo, J.-P., Kamei, A., Mizunoya, S., & Ortiz Correa, J. S. (2020). Promising Practices for Equitable Remote Learning. Emerging lessons from COVID-19 education responses in 127 countries. *Innocenti Research Briefs*, 2020-10.

European Investment Bank (2022, April 12). Digital Tools could bridge educational gaps created by the COVID-19 pandemic. European Investment Bank. https://www.eib.org/en/essays/covid-19-digital-education

El Nabahany, U., Mosbech, A.-M., Mgeni, M., & Yunus, S. (2019). A transformation into digitally supported education: Case from the State University of Zanzibar. In *Sustainable ICT, Education and Learning. IFIP Advances in Information and Communication Technology*, 564, 16-23. https://doi.org/10.1007/978-3-030-28764-1_3

Facer, K., & Selwyn, N. (2021). *Digital Technology and the Futures of Education: Towards "Non-Stupid" Optimism*. Unesco. https://unesdoc.unesco.org/ark:/48223/pf0000377071

Gentry, S. V., Gauthier, A., L'Estrade Ehrstrom, B., Wortley, D., Lilienthal, A., Tudor Car, L., Dauwels-Okutsu, S., Nikolaou, C. K., Zary, N., Campbell, J., & Car, J. (2019). Serious gaming and gamification education in Health Professions: Systematic Review. *Journal of Medical Internet Research*, *21* (3). https://doi.org/10.2196/12994

George, P. P., Zhabenko, O., Kyaw, B. M., Antoniou, P., Posadzki, P., Saxena, N., Semwal, M., Tudor Car, L., Zary, N., Lockwood, C., & Car, J. (2019). Online Digital Education for postregistration training of medical doctors: Systematic review by the Digital Health Education Collaboration. *Journal of Medical Internet Research*, *21* (2). https://doi.org/10.2196/13269

Georgsen, M., & Løvstad, C. V. (2014). Use of blended learning in workplace learning. *Procedia – Social and Behavioral Sciences*, 142, 774-780. https://doi.org/10.1016/j.sbspro.2014.07.614

Gorbunovs, A. (2021). The review on eye tracking technology application in Digital Learning Environments. *Baltic Journal of Modern Computing*, *9* (1), 1-24. https://doi.org/10.22364/bjmc.2021.9.1.01

Jiang, Q., & Xu, X. (2016). Strategy of Digital Education Resources Construction in Cloud-Computing Environment. In *Eighth International Conference on Measuring Technology and Mechatronics Automation (ICMTMA)*, Macau, China, 632-635. https://doi.org/10.1109/ICMTMA.2016.155

Jones, T., Marimuthu, K., & Bearman, G. (2022). Virtual infection prevention and control in low- and middle-income countries. *International Journal of Infectious Diseases*, 117, 93-96. https://doi.org/10.1016/j.ijid.2022.01.065

Khan, M. A. (2021). Covid-19's impact on Higher Education: A rapid review of early reactive literature. *Education Sciences*, *11* (8), 1-14. https://doi.org/10.3390/educsci11080421

Kyaw, B. M., Posadzki, P., Paddock, S., Car, J., Campbell, J., & Tudor Car, L. (2019). Effectiveness of digital education on communication skills among medical students: Systematic review and meta-analysis by the Digital Health Education Collaboration. *Journal of Medical*

Internet Research, *21* (8). https://doi.org/10.2196/12959; https://doi.org/10.2196/12967; https://doi.org/10.2196/14984; https://doi.org/10.2196/13165

Lakkala, M., Ilomäki, L. & Palonen, T. (2007). Implementing Virtual Collaborative Inquiry practises in a middle-school context. *Behaviour & Information Technology*, *26* (1), 37-53. https://doi.org/10.1080/01449290600811529

Lameras, P., & Moumoutzis, N. (2021). Towards the development of a digital competency framework for Digital Teaching and learning. In *IEEE Global Engineering Education Conference (EDUCON)*, Vienna, Austria, 1226-1232. https://doi.org/10.1109/EDUCON46332.2021.9454027

Lopukhova, Y., Makeeva, E., & Zhuravleva, O. (2019). New horizons of internationalisation through e-learning: Developing teacher digital competence. In *International Forum on Teacher Education (ARPHA Proceedings)*, Kazan Federal University, Russia, 561-573. https://doi.org/10.3897/ap.1.e0391

Luck, L. T., Hashim, F., & Din, S. Z. (2012). A creative and literary writing digital LMS in supporting writers' Group Learning and Knowledge Sharing among creative writers. *Procedia – Social and Behavioral Sciences*, 67, 238-249. https://doi.org/10.1016/j.sbspro.2012.11.326

Luong, J., & Arnold, R. (2020). Creating a digital learning community: Four key considerations for remote learning during a pandemic. In *IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE)*, Takamatsu, Japan, 786-791. https://doi.org/10.1109/TALE48869.2020.9368385

Maqsood, A., Abbas, J., Rehman, G., & Mubeen, R. (2021). The paradigm shift for educational system continuance in the advent of COVID-19 pandemic: Mental Health Challenges and reflections. *Current Research in Behavioral Sciences*, 2, 1-5. https://doi.org/10.1016/j.crbeha.2020.100011

Martinengo, L., Yeo, N. J., Tang, Z. Q., Markandran, K. D. O., Kyaw, B. M., & Tudor Car, L. (2019). Digital Education for the management of chronic wounds in health care professionals: Protocol for a systematic review by the Digital Health Education Collaboration. *JMIR Research Protocols*, *8* (3). https://doi.org/10.2196/12488

Medina, M. (n. d.). The Digital Education Revolution: Time to invest in digitalization. Hospitality News & Business Insights by EHL. https://hospitalityinsights.ehl.edu/digital-education-revolution

Mills, H. (2015). Use of mobile devices for e-learning in Geomatics. In *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, ISPRS Workshop of Commission VI*, Berlin, Germany, XL-6/W1, 5-8. https://doi.org/10.5194/isprsarchives-XL-6-W1-5-2015

Müller, C., & Mildenberger, T. (2021). Facilitating flexible learning by replacing classroom time with an online learning environment: A systematic review of blended learning in higher education. *Educational Research Review*, 34, 1-16. https://doi.org/10.1016/j.edurev.2021.100394

Nasiri, M., Ukko, J., Saunila, M., & Rantala, T. (2020). Managing the Digital Supply Chain: The role of smart technologies. *Technovation*, 96-97, 1-6. https://doi.org/10.1016/j.technovation.2020.102121

Ninaus, M., Greipl, S., Kiili, K., Lindstedt, A., Huber, S., Klein, E., Karnath, H.-O., & Moeller, K. (2019). Increased emotional engagement in game-based learning – A machine learning approach on facial emotion detection data. *Computers & Education*, 142, 1-10. https://doi.org/10.1016/j.compedu.2019.103641

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw,

J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The Prisma 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*. https://doi.org/10.1136/bmj.n71

Perevalova, A., Resenchuk, A., & Tunyova, N. (2020). Teaching professional vocabulary to the students in coal region universities through Digital Educational Tools. In *Vth International Innovative Mining Symposium (E3S Web of Conferences)*), 174, 1-8. https://doi.org/10.1051/e3sconf/202017404051

Philippe, S., Souchet, A. D., Lameras, P., Petridis, P., Caporal, J., Coldeboeuf, G., & Duzan, H. (2020). Multimodal teaching, learning and training in virtual reality: A review and case study. *Virtual Reality & Intelligent Hardware*, *2* (5), 421-442. https://doi.org/10.1016/j.vrih.2020.07.008

Radchenko, G., & Pervukhina, S. (2020). Interactivity in digital teaching of a foreign language (on the example of Don State Technical University). In *ITSE-2020 (E3S Web of Conferences)*, 210, 1-10. https://doi.org/10.1051/e3sconf/202021018036

Rahayu, N. W., Ferdiana, R., & Kusumawardani, S. S. (2022). A systematic review of ontology use in E-learning recommender system. *Computers and Education: Artificial Intelligence*, 3, 1-16. https://doi.org/10.1016/j.caeai.2022.100047

Saint, J., Fan, Y., Gašević, D., & Pardo, A. (2022). Temporally-focused analytics of self-regulated learning: A systematic review of literature. *Computers and Education: Artificial Intelligence*, 3, 1-22. https://doi.org/10.1016/j.caeai.2022.100060

Seow, C. S., Lomanto, D., & Ooi, L. L. (2022). Covid-19 and the impact on surgical training and education in Singapore. *Heliyon*, *8* (1), 1-3. https://doi.org/10.1016/j.heliyon.2022.e08731

Soellner, S. (2021). Digital elements for SAP ERP education and training: Results from a systematic literature review. *International Journal of Engineering Pedagogy*, *11* (4), 1-15. https://doi.org/10.3991/ijep.v11i4.21843

Steinbuß, S., Holtkamp, B., & Opriel, S. (2017). Handelkompetent – situation aware learning in retail. *Procedia Manufacturing*, 9, 245-253. https://doi.org/10.1016/j.promfg.2017.04.048

Stevens, G. J., Bienz, T., Wali, N., Condie, J., & Schismenos, S. (2021). Online University education is the new normal: But is face-to-face better?. *Interactive Technology and Smart Education*, *18* (3), 278-297. https://doi.org/10.1108/ITSE-08-2020-0181

Suzuki, K., Kondo, H., Yamaguchi, S., Ohnishi, Y., Tsumori, S., Wakana, H., & Nishino, K. (2014). Development of learning methods and systems to practice problems using digital materials. *Procedia Computer Science*, 35, 1247-1254. https://doi.org/10.1016/j.procs.2014.08.222

Sánchez, A. D., de la Cruz Del Río Rama, M., & García, J. Á. (2017). Bibliometric analysis of publications on Wine Tourism in the databases scopus and WOS. *European Research on Management and Business Economics*, *23* (1), 8-15. https://doi.org/10.1016/j.iedeen.2016.02.001

Thahir, M., Widiawati, W., & Baitillah, N. (2023). The Post Pandemic Education: A Blended Learning Approach for Teaching and Learning in Higher Education in New Normal Era. *International Journal of Ethno-Sciences and Education Research*, *3* (3), 99-108. https://doi.org/10.46336/ijeer.v3i3.461

Vallée, A., Blacher, J., Cariou, A., & Sorbets, E. (2020). Blended learning compared to traditional learning in medical education: Systematic Review and meta-analysis. *Journal of Medical Internet Research*, *22* (8). https://doi.org/10.2196/16504

Versteijlen, M., Perez Salgado, F., Janssen Groesbeek, M., & Counotte, A. (2017). Pros and cons of online education as a measure to reduce carbon emissions in higher education in the

Netherlands. *Current Opinion in Environmental Sustainability*, 28, 80-89. https://doi.org/10.1016/j.cosust.2017.09.004

Wahabi, H. A., Esmaeil, S. A., Bahkali, K. H., Titi, M. A., Amer, Y. S., Fayed, A. A., Jamal, A., Zakaria, N., Siddiqui, A. R., Semwal, M., Car, L. T., Posadzki, P., & Car, J. (2019). Medical doctors' offline computer-Assisted Digital Education: Systematic review by the Digital Health Education Collaboration. *Journal of Medical Internet Research*, *21* (3). https://doi.org/10.2196/12998

Wakefield, A. B., Carlisle, C., Hall, A. G., & Attree, M. J. (2008). The expectations and experiences of blended learning approaches to patient safety education. *Nurse Education in Practice*, *8* (1), 54-61. https://doi.org/10.1016/j.nepr.2007.04.007

Yin, X. (2021). Stimulation and maintenance in the construction of Digital Learning Resources: A study of online learners' learning interests. *OALib*, *08* (07), 1-13. https://doi.org/10.4236/oalib.1107556; https://doi.org/10.4236/oalib.1107595

Zeqiri, J. (2021). The impact of blended learning on students' performance and satisfaction in South East Europe. *Economic Thought and Practice*, *30* (2), 325-344. https://doi.org/10.1504/IJTEL.2021.115982

Zitzmann, N. U., Matthisson, L., Ohla, H., & Joda, T. (2020). Digital Undergraduate Education in Dentistry: A systematic review. *International Journal of Environmental Research and Public Health*, *17* (9), 1-23. https://doi.org/10.3390/ijerph17093269

Živković, S. (2022). Inspiring digital transformation: An integrative leadership competency framework. *Economic Thought and Practice*, *31* (1), 71-88. https://doi.org/10.17818/EMIP/2022/1.11

Dr. sc. Kateřina Petrová

Docentica
Tehnološko sveučilište u Brnu, Češka Republika
Fakultet za poslovanje i menadžment
Email: xphornungova@vutbr.cz
Orcid: https://orcid.org/0000-0002-6895-1238

Dr. sc. Jana Hornungová

Docentica
Tehnološko sveučilište u Brnu, Češka Republika
Fakultet za poslovanje i menadžment
Email: Jana.Hornungova@vut.cz
Orcid: https://orcid.org/0000-0001-5788-4044

IMPLIKACIJA COVID-19 PANDEMIJE NA DIGITALNO OBRAZOVANJE: SUSTAVNI PREGLED LITERATURE

Sažetak

Cilj je istraživanja procijeniti trenutno stanje digitalnog obrazovanja identificiranjem razlika između hibridnih i tradicionalnih modela učenja ispitivanjem utjecaja pandemije COVID-19 na digitalno obrazovanje te utvrđivanjem multimedijskih i digitalnih alata koji se koriste u procesu učenja. Sustavno pretraživanje literature provedeno je korištenjem PRISMA smjernicama, što je rezultiralo odabirom 50 recenziranih članaka s otvorenim pristupom objavljenih između 2007. i 2022. godine. Istraživanja su analizirana s pomoću softvera MAXQDA i grupirana u tri tematske kategorije usklađene s istraživačkim pitanjima. Nalazi pokazuju da digitalno obrazovanje postaje neizostavna komponenta moderne pedagogije, promičući interaktivna i intuitivna iskustva učenja. Alati kao što su gemifikacija, virtualna stvarnost i multimedijske platforme poboljšavaju angažman studenata, suradnju i kreativnost. Unatoč tome, izazovi i dalje postoje, uključujući ograničenu infrastrukturu i nisku digitalnu pismenost u kontekstima s nedovoljno resursa. Istraživanje doprinosi ovom području nudeći praktične uvide i preporuke za edukatore, kreatore politika te istraživače koji teže izgradnji uključivih i održivih okruženja za digitalno učenje.

Ključne riječi: digitalno obrazovanje, digitalno učenje, e-učenje, COVID-19.

JEL klasifikacija: I21, O33, I19.