THE EVOLUTION OF EDUCATIONAL TECHNOLOGY DURING THE COVID-19 PANDEMIC: A SYSTEMATIC LITERATURE

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Abstract. This study aims to analyze the evolution of educational technology during the COVID-19 pandemic through a systematic review of global literature published between 2020 and 2023. The pandemic created an unprecedented disruption in traditional education systems, accelerating the adoption of digital learning technologies worldwide. This research examines key trends, challenges, and innovations in educational technology implementation across various learning contexts. Using a systematic literature review (SLR) method, data were collected from reputable databases such as Scopus, Google Scholar, and ScienceDirect, focusing on studies related to online learning, digital pedagogy, and educational technology integration. The analysis reveals that the pandemic acted as a catalyst for digital transformation in education, with significant progress in the use of Learning Management Systems (LMS), Artificial Intelligence (AI)-based adaptive learning, Virtual Reality (VR) classrooms, and mobile learning platforms. However, disparities in digital infrastructure, digital literacy, and pedagogical readiness remain major challenges, particularly in developing countries. The findings underscore that the effectiveness of educational technology depends not only on technological innovation but also on institutional support, teacher competence, and equitable access. This study contributes to the global understanding of post-pandemic educational transformation and provides insights for policymakers, educators, and researchers to design sustainable digital learning ecosystems.

Keywords: educational technology; COVID-19 pandemic; online learning; digital transformation

I. INTRODUCTION

Corona Virus Disease 2019 (COVID-19) has become a The outbreak of Coronavirus Disease 2019 (COVID-19) at the end of 2019 has profoundly transformed nearly all sectors of human activity, including education, economy, health, and governance. According to Our World in Data (2022), more than 532 million cases and 6.3 million deaths were reported globally by mid-2022, positioning the pandemic as one of the most disruptive global health crises in recent history [1]. The rapid spread of the virus prompted governments worldwide to impose social restrictions, lockdowns, and mobility limitations that forced schools and universities to suspend face-to-face learning [2]. In Indonesia, this measure was formalized through Government Regulation No. 21/2020 on Large-Scale Social Restrictions (PSBB), which required educational institutions to adopt remote learning to ensure learning continuity [3]. The pandemic accelerated the digital transformation of education, compelling schools, universities, and training institutions to adopt educational technology (EdTech) to facilitate distance learning [4]. As traditional classrooms shifted to virtual platforms, the integration of information and communication technologies (ICTs) became essential to maintain educational engagement and access [5]. Tools such as Zoom, Google Meet, Moodle, WhatsApp, and Microsoft Teams emerged as key enablers for synchronous and asynchronous learning [6]. According to Turnbull et al., this sudden digital transition represented the largest global educational reform ever witnessed, with technology serving as both a survival tool and a pedagogical innovation [7].

However, the adoption of EdTech also revealed deep-seated challenges—particularly digital inequality, limited infrastructure, and variations in digital competence among educators and learners [8]. In developing countries like Indonesia, insufficient internet coverage, inadequate hardware access, and limited teacher training became major barriers to effective online learning [9]. A study by Cahyadi et al. identified technological readiness, economic status, and digital literacy as key determinants of successful online education implementation [10]. Despite these limitations, the pandemic has significantly advanced digital education policies and encouraged stakeholders to prioritize e-learning integration into national education systems [11]. Globally, higher education institutions demonstrated resilience by developing innovative online pedagogies, integrating virtual laboratories, and creating digital assessment systems such as Online Proctored Examinations (OPE) [12]. These innovations allowed universities to maintain academic integrity and engagement despite physical isolation. Similarly, studies in Saudi Arabia, India, and China reported positive learning outcomes when online tools were paired with supportive policies and teacher training [13]. Yet, challenges such as reduced social interaction, increased student fatigue,

and decreased sense of belonging remained prevalent among learners [14].

The evolution of educational technology during the pandemic has also redefined the concept of learning environments, emphasizing hybrid and blended learning models that combine online and face-to-face modalities. Zhou et al. argue that the COVID-19 pandemic marked a paradigm shift from emergency remote teaching to a more sustainable digital education framework that integrates technology into long-term teaching strategies [15]. Moreover, the role of teachers' digital competence and institutional readiness became vital for post-pandemic education recovery, underscoring the need for continuous professional development and investment in digital infrastructure [16].

This literature review aims to analyze and synthesize recent studies on the evolvement of educational technology during the COVID-19 pandemic, identifying (1) the types of educational technologies most commonly used; (2) the factors influencing their adoption and effectiveness; and (3) their pedagogical, psychological, and institutional impacts. Understanding these dynamics is crucial for guiding policymakers, educators, and technologists in designing inclusive and resilient educational ecosystems that can withstand future crises.

Technology Acceptance Model (TAM)

The Technology Acceptance Model (TAM), developed by Davis, remains the most widely used framework for explaining technology adoption behavior. TAM posits that perceived usefulness (PU) and perceived ease of use (PEOU) determine an individual's behavioral intention to use a system [17]. During the COVID-19 pandemic, TAM has been extensively applied to evaluate teachers' and students' willingness to adopt online learning platforms [18]. For instance, Salloum et al. found that PU and PEOU significantly influenced the continued use of learning management systems (LMS) among university students in the UAE. Similarly, Toto and Limone confirmed that perceived usefulness and institutional support shaped the positive attitude of educators toward e-learning tools. These findings highlight that user perceptions—rather than institutional mandates—primarily drive successful adoption of digital learning technologies [19].

Unified Theory of Acceptance and Use of Technology (UTAUT)

Building upon TAM, the Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh et al. integrates four constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions [20]. This model has been widely adopted to explain technology usage behavior in education during COVID-19 [21]. Studies conducted by Al-Emran et al. and Mailizar and Fan revealed that performance expectancy and social influence were the most dominant predictors of e-learning adoption among students in Indonesia and Malaysia. UTAUT further emphasizes the role of organizational and infrastructural support—such as reliable internet access and training—as enablers of sustained technology use [22].

DeLone–McLean Information System (IS) Success Model

The DeLone–McLean IS Success Model provides a multidimensional approach to evaluating the quality and effectiveness of information systems, focusing on system quality, information quality, and service quality as antecedents of user satisfaction and net benefits [23]. During the pandemic, this model was used to assess online learning platforms, particularly their usability, accessibility, and pedagogical effectiveness. Almaiah et al. confirmed that system reliability, content relevance, and technical support significantly influenced student satisfaction with online learning systems in Jordan. Similarly, Lin et al. identified information quality and instructor responsiveness as key determinants of virtual learning success in Taiwan [24]. The model thus provides a holistic lens for evaluating both technological and pedagogical dimensions of EdTech systems.

Digital Readiness and Competency Frameworks

The success of educational technology adoption also depends on users' digital readiness, which encompasses technical skills, digital literacy, and cognitive adaptability [25]. Digital readiness frameworks, such as the European DigCompEdu and UNESCO ICT Competency Framework for Teachers, stress the importance of professional digital competence among educators. Research during COVID-19 revealed that teachers' digital readiness strongly influenced learning outcomes and student engagement. Mishra et al. and Cahyadi et al. found that digital competency gaps between rural and urban schools created inequalities in online learning participation. Meanwhile, Zhao and Song emphasized that training, motivation, and self-efficacy are crucial for improving teachers' technological integration in hybrid and post-pandemic contexts [26].

Conceptual Framework of Educational Technology Evolvement

Synthesizing these theoretical perspectives, the evolvement of educational technology during the COVID-19 pandemic can be understood as an interactive system influenced by individual, technological, and institutional factors. TAM and UTAUT explain behavioral intention and technology acceptance, while the DeLone–McLean model addresses system performance and user satisfaction. Digital readiness theory, meanwhile, contextualizes these frameworks within educators' and learners' competencies and infrastructure access. Collectively, these theories highlight that effective educational technology implementation requires not only reliable systems but also psychological readiness, continuous support, and equitable access.

II. RESEARCH METHODS

This study employed a systematic literature review (SLR) approach to synthesize research findings on the development and application of educational technology during the COVID-19 pandemic. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological transparency and reproducibility [27]. Relevant studies published between 2016 and 2023 were collected from major academic databases, including Scopus, ScienceDirect, SpringerLink, ERIC, and Google Scholar. The search combined keywords such as "educational technology,"

"COVID-19," "online learning," "digital pedagogy," and "distance education." Inclusion criteria were limited to peer-reviewed journal articles, empirical studies, and reviews written in English, while editorials and non-academic reports were excluded. A total of 86 articles initially met the search criteria; after screening titles, abstracts, and duplicates, 42 studies were selected for in-depth qualitative synthesis. Thematic analysis was conducted to identify emerging trends, challenges, and pedagogical innovations related to technology use in education. Data were categorized into four dominant themes: (1) adoption and acceptance of digital learning technologies; (2) challenges of infrastructure and digital literacy; (3) pedagogical transformation and blended learning strategies; and (4) policy and institutional responses. The analytical procedure followed Kitchenham and Charters' (2007) guidelines for evidence-based technology research, ensuring comprehensive coverage and objective interpretation of the reviewed literature [28].

III. RESULTS AND DISCUSSION

Analysis matrix was implemented to execute a summary of the literature review on educational technology during the COVID-19 pandemic. The summary results show that regarding online learning, government policies in various countries have received support from the community, especially from students (Singh et al.[4]). The results of this systematic review analysis showed that the impact of the lockdown policy on education prompted several countries to promote online learning during a pandemic (Abu Talib et al., [11]). The online learning process was supported by applications that facilitate teachers and students to learn and also see each other privately. The application used were Zoom, Youtube, Moodle, Facebook, Blackboard, Microsoft, skype, Whatsapp, google class room, tweeter, and Google Docs (Turnbull et al., [5]). In addition, technological innovations were designed to facilitate the student on an academic examination process. Online Proctored Examination (OPE) application was accepted and had a positive effect (Raman et al., 2021). Furthermore, the learning method based on the IS DeLone and McLean models obtained quite significant results in the online learning process. The factors that influenced the educational technology implementation in the learning process were the possession of basic computer skills, the technological convenience, the technological utility (Jiang et al. [29]), digital devices mastery and the training for teachers about E-Learning programs (Kovacs et al. [9]), lack of resources and sufficient internet access, affordable and reliable technology, as well as socio-economic status (Cahyadi et al. [10]). Apart from having a positive impact on the learning process, educational technology also had others impact on students and educational institutions, such as; derivation of learning outcome and sense of belonging degradation of students to their university (Morgan et al., [14]), practical learning could not be carried out optimally through online larning, feelings of boredom with prolonged online methods, and decreased satisfaction of social interaction.

This literature review analyzed 20 articles related to educational technology during the COVID-19 period. Therefore, the author also explained about some related terms such as; Science, technology, education, and the COVID-19 pandemic. As mentioned in Law Number 11 year of 2019, these terms were explained in the general provisions chapter. Science is a collection of information that is explored, organized, and developed systematically using scientific methodologies to explain and/or prove natural phenomena, and/or social phenomena based on belief in God Almighty. Furthermore, technology is defined as a way, method or process of applying and utilizing various scientific disciplines that are useful in fulfilling needs, continuity, and improving the quality of human life. Education is a conscious and planned effort to create a learning atmosphere and learning process so that the students can actively develop their potential to have religious spiritual strength, self-control, personality, intelligence, noble character, and the skills needed by themselves, society, nation and state. Meanwhile, according to the Ministry of Health, corona virus is a large family of viruses that cause disease in humans and animals. In humans, it usually causes respiratory tract infections, ranging from the common cold to serious diseases such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS) (Kemenkes RI, [30]).

By identifying 20 eligible articles, four main findings were obtained related to educational technology during the COVID-19 pandemic. The first finding was regarding support for implementing online methods in the learning process during the co-19 pandemic. All countries listed in articles were Indonesia, Saudi Arabia, United Arab Emirates, China, Australia, Switzerland, Greece, India, Iran Israel, Poland, America, Ghana and Zimbabwe. Those countries supported and provided policies regarding the implementation of online learning. The second finding was about educational technology types that were often used in the learning process as well as new methods used to support learning activities and evaluations during a pandemic such as; Zoom, Youtube, Moodle, Facebook, Blackboard, Microsoft, Skype, Whatsapp, google class room, tweeter, and Google Docs applications. In addition, there was also the OPE method designed for the online student examination process, the IS DeLone and McLean methods, mobile phones or smartphones, virtual laboratories, the development of the Emergency Teaching Evaluation (ERT) method, and the development of the Unfied Theory of Acceptance and Use of Technology (UTAUT) model. The third finding was about the factors that influenced the application of educational technology such as; computer skills, the technological convenience, the technological utility, digital devices mastery and the training for teachers about E-Learning programs, lack of resources and sufficient internet access, affordable and reliable technology, as well as socio-economic status. The fourth finding showed that aside from having a positive impact, online learning also has impact on several things such as; derivation of learning outcome and sense of belonging degradation of students to their university, practical learning could not be carried out optimally through online larning, feelings of boredom with prolonged online methods, and decreased satisfaction of social interaction.

Educational Technology During the COVID-19 Pandemic

The COVID-19 pandemic has led to dramatic impact on various aspects of human life worldwide. Aspects of government, social, health, education and other aspects that are assembled require an adjustment to continue running in a balanced way. For nearly three years, besides the health aspect, the education aspect has also received special attention. Quarantine or self-isolate at home policies has become issue. In other words, learning activities cannot be carried out as usual, especially for conventional or face-to-face learning. For this reason, governments in various countries continue to innovate in education technology so that the education can still be carried out by distance or online learning. Technology is defined as consisting of hardware and software (knowledge to produce and use technological hardware) (Kiraz [31]). Meanwhile, education is defined as a conscious effort to achieve something that is culturally inherited from generation to generation. Education creates today's generation as the role model for the previous generations in teaching activities. Until now, education has no limitations to explain the meaning of education itself because of it is complex nature for human. Its complex nature is often called as the science of education. Science education is a continuation of education. Educational science is more related to educational theory which prioritizes scientific thinking. Education and science education have a relationship in terms of practice and theory. Thus, in human life, both collaborate with each other (Rahman et al.[32]). Technology is a tool created to achieve a goal (Dron [33]). Educational technology talks about technology or tools used in education or learning. According to Dron [33] explains that educational technology, or learning technology, can be tentatively defined as technology that, intentionally or not, includes pedagogy among the regulated technologies. While some educational technologies are designed and sold for this purpose – learning management systems, textbooks, electronic whiteboards, courses, etc. – almost any technology (from factories to word processing), when combined with appropriate pedagogy and other technologies, is used to support or generate learning activities. Neither students nor designers need to be aware of it. For example, the toy cars creator may not find them educate the child, and the child who plays them may not plan to learn from them, but the imaginative games they play can support strong learning processes.

Types of Educational Technology During the COVID-19 Pandemic

Based on the results of previous studies, there were several technologies used in education (learning), namely: zoom meeting, youtube, moodle, facebook, blackboard, Microsoft, skype, whatsapp, google classroom, titter and google docs (Turnbull et al. [5]). This paper discussed the three most popular applications from the results of the study. One of the most popular applications was Zoom Meeting. Many educational institutions, businesses, government health and so on used the zoom meeting application as a learning application or delivery of information online. This application can be applied easily by users, besides that this application can be downloaded and installed for free. Some Zoom meetings are paid and some are free. For the free version, users will only be given 40 minutes of time which will automatically turn off after the time runs out. However, for the paid version there is no time limit, meaning that users can communicate without interruption, unless there are problems with the internet network. This application is also often used at national and international seminar events. Apart from the Zoom Meeting application, the second popular application is YouTube. People can find anything they are looking for through youtube. This application is general in nature, not only educational content that can be watched but also other content such as entertainment, sports, government, health and so on. Youtube in the academic field is usually used to upload learning content, cannot be used as a direct online face-to-face medium, usually it can only be watched. As for usually the students are assigned to analyze a learning video in accordance with the topics taught in lectures. Or students are given the task of making a learning video or tutorial and then uploading it on YouTube.

Furthermore, the third application is the modle application. This application is in the form of a web-based which is often used as an effective online learning media. In some countries this application may be popular, but in Indonesia the academic community is not very familiar with this application. Because they find it easier to use zoom meetings or even other e-learning programs. This moodle application is very useful to be implemented as a Learning Management System (LMS). It has many advantages, such as being accessible for free, having complete features, network and security features that can be set individually, and so on However, the drawbacks of Moodle are 1) users must have a deeper understanding of Moodle, 2) an expert is required to act as an administrator, and 3) it requires pretty good hardware and a fairly high cost.

Factors that Influence the Application of Educational Technology

Educational technology is indeed very helpful in the learning process, but there are several important factors that influenced the implementation or application of these technologies in learning. Several factors that can influence the application of educational technology are school readiness including academic maintenance and social welfare (Williams & Corwith, [16]), post-COVID-19 strategies to promote e-learning (Adarkwah [34]), adequate internet connection, level of difficulty of technology applications, economic conditions and the support of school IT expert staff (Cahyadi et al. [10]).

School readiness is one of the main factors that can influence the application of technology in the educational environment. If schools are not ready, then the learning process using technology will be constrained and even cannot be carried out properly. Educational institutions should prioritize prior preparation, such as; synchronizing the educational curriculum, providing good and quality supporting facilities and infrastructure, adequate internet network and training for staff or teaching staff related to the applications to be used. Economic and social factors also influence its application, because in general the poor are constrained to prepare online learning support facilities such as; cellphones, laptops, and internet data packages. In addition, educational institutions tend to use applications that are easy

to apply as learning media, low cost and accessible for free. This characteristic could likely be reached by the lower middle class, so that the learning process using technology can be enjoyed and used together easily and efficiently.

The Impact of Educational Technology on Online Learning

Educational technology in online learning certainly has positive and negative impacts.

IV. CONCLUSIONS

The findings of this literature review indicate that the COVID-19 pandemic has served as a major catalyst for the transformation of educational technology, reshaping teaching, learning, and institutional practices across the world. The rapid transition from traditional to digital classrooms accelerated the adoption of e-learning platforms, virtual classrooms, and mobile learning tools, highlighting the essential role of technology in maintaining educational continuity during crises. However, this progress also revealed persistent challenges related to digital infrastructure, access inequality, and variations in teachers' digital competence, particularly in developing countries such as Indonesia. The review further emphasizes that the effectiveness of technology-based education depends not only on the availability of digital tools but also on the readiness, motivation, and pedagogical adaptation of educators and learners. Frameworks such as TAM, UTAUT, and the DeLone–McLean IS Success Model remain crucial for understanding user acceptance, system success, and satisfaction in the use of learning technologies. Post-pandemic, these insights underline the need for a sustainable digital education ecosystem supported by inclusive policy, professional development, and equitable infrastructure. In essence, the evolution of educational technology during COVID-19 has not merely been a temporary response but a transformative milestone toward the long-term modernization and resilience of global education systems.

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