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Digital transformation of education in Croatia: current state, economic aspects, and development potential

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Abstract

This paper analyses the state of digitalisation in Croatian education, focusing on the availability of digital tools, teachers' perceptions of their use and the economic impact of technology-enhanced teaching. The study includes survey results from the educational staff, which analysed how they perceive access to and use of digital tools, the quality of online teaching compared to traditional teaching and general readiness for further digital transformation. The results confirm that access to technology and well-developed digital skills have a positive impact on teaching quality, while strategic investment in digitalisation brings long-term educational and economic benefits. It concludes with recommendations for a more balanced and effective implementation of digital technologies that are aligned with the educational needs of 21st century learners.

Keywords: digitalisation of education, digital competencies, educational technology, Croatia, online teaching

1. Introduction

From the 1980s, the spread of personal computers made technology more accessible and introduced computer literacy as part of basic education (Rogers, 2003). The 1990s brought the internet, enabling global access to information, online collaboration, and the first learning management systems such as Moodle and Blackboard (Teo, 2011). At the turn of the 21st century, broadband and MOOCs like Coursera and edX expanded e-learning worldwide (Selwyn, 2016; Bates, 2015). Today, advanced technologies, including artificial intelligence (AI), virtual reality (VR), augmented reality (AR), big data, and Internet of Things (IoT) are transforming teaching and learning practices, while hybrid models, accelerated by the COVID-19 pandemic, combine the benefits of online and traditional classrooms to provide flexibility and inclusivity. Digital technologies in education have evolved through several phases, from the earliest experiments with computers in schools to today's advanced online platforms and hybrid models, each stage reshaping teaching and learning by increasing accessibility, personalisation, and interactivity (Selwyn, 2016). The introduction of programmed learning marked the beginning of computer-based education, enabling students to learn at their own pace while receiving feedback from instructors (Bates & Poole, 2003). Rather than privileging memorisation, Education 4.0 leans into experiential, technology enabled, personalised learning, which is an approach mirrored in recent literature that stresses digital transformation and the targeted use of particular educational technologies (Mukul & Buyukozkan, 2023).

E-learning defines the educational process that uses electronic technologies, primarily the internet, for knowledge transfer and skills development. Nowadays, e-learning is being used at all levels of education and it has become a key element of modern education, because it offers flexible and accessible learning while at the same time enables the personalisation of learning (Luckin et al., 2016). However, despite its advantages, e-learning faces several challenges, including unequal access to technology, reduced social interaction, and the need for strong self-regulation among learners (Warschauer, 2004; Moore, 1993; Barnard et al., 2009). The quality of content also varies, highlighting the need for standards and quality assurance (Bates, 2005). Today, e-learning is widely applied in formal education, vocational training and lifelong learning, often as part of hybrid models (Means et al., 2010; Selwyn, 2016).

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2. Literature review

Nowadays, digital transformation is essential for higher education (Li, 2024). Digital transformation has become a key factor in educational development, involving not only disruptive technologies but also enabling higher education institutions (HEIs) to respond to society changes and labour market demands (Aquino et al., 2025). Moreover, digital transformation in higher education strengthens learning outcomes and digital literacy while utilising technology to improve teaching, communication, and evaluation ((Dimitrova & Marinova, 2024). ICT has been central to this process, enabling new teaching and learning approaches, driving change in education, and creating opportunities for innovative methods and strategies (Arkhipova et al., 2024). Therefore, education systems must be transformed to provide students the digital skills they need to meet the demands of the labour market and global digitisation (Narkoziev et al., 2024).

Education 5.0, driven by the fifth industrial revolution, uses advanced digital technologies to create a learner-centric environment. It aims to enhance learning, remove barriers, and foster personalised learning, collaboration, and wellbeing (Rubeena & Ansari, 2024). Through tools such as AI, VR/AR, and IoT, it promotes 21st century skills (critical thinking, creativity, and problem-solving) over rote learning and seeks to build an equitable, adaptable education system for a changing society (Ahmad et al., 2023). However, its success depends on overcoming major challenges while preparing well-rounded individuals with creativity, critical thinking, and ethical decision-making skills (Rubeena & Ansari, 2024). In that regard, previous research in Croatia applied a SWOT analysis considering e-learning and identifying strengths such as increased flexibility, accessibility, and greater student activity and independence, but also highlighting threats including digital inequality, lack of systematic approach, and social isolation (Ježić & Škulić, 2022). At the same time, the evolution of HEIs is inevitable as technological advances reshape their traditional roles in creating, transmitting, and preserving knowledge (Meter & Setiawan, 2023). The digital transformation of higher education is essential for creating a workforce that is prepared for the future. This will create a flexible, equitable, and effective system that can adjust to societal shifts and the demands of the next industrial revolution (Bhatia et al., 2021). As society adapts to society 5.0, higher education must undergo a paradigm shift to align programmes with the needs of industry and society. Digital technologies enable adaptive, collaborative, and personalised learning, while digital literacy and upskilling of educators are essential to ensure quality education. Developing innovative curricula, fostering human-centric skills, and strengthening industry collaboration are the three priorities that stand out for preparation of a future-ready workforce (Shahidi Hamedani et al., 2024).

The development and implementation of Education 5.0 must be guided by a clear vision of what education should achieve, going beyond knowledge and skills to encourage critical thinking, creativity, and ethical decision-making (Rubeena & Ansari, 2024). Therefore, this study aims to assess the current state of digital transformation in Croatia and provide clear directions for future implementation.

Moreover, digitalisation in education has important economic effects that can be seen through investments in human capital, productivity gains, and cost optimisation. Ježić et al. (2022) highlight the importance of investing in ICT and education in order to achieve higher human development levels. Investment in technology do not represent solely hardware and software investments, they include strategic investment in teacher training and student digital skills as well, which directly affects employability and long-term economic growth (OECD, 2018). Learning management systems reduce administrative workloads, while hybrid models can lower instructional costs by 20–40% and improve student outcomes by 15–25% (Selwyn, 2016; Christensen et al., 2013). At the macro level, education supported by digital skills enhances GDP growth and reduces youth unemployment by bridging the skills gap in the labour market (OECD, 2018; World Economic Forum, 2020). While investments in infrastructure and teacher training increase the resilience of education systems in times of crisis, digital inclusion also guarantees access for students in rural areas, promoting equity and local development (Zawacki-Richter & Jung, 2023). Moreover, in addition to improving instructional efficiency, digital transformation restructures HEI business models, shifting them from logics that rely solely on tuition to value that is enabled by platforms (micro-credentials, lifelong learning services, and data-driven student assistance). However, this comes with organisational challenges that need to be actively handled (Mukul & Buyukozkan, 2023; Rof, et al., 2020). Institutions are making progress when digital investments are linked to new service portfolios and process redesigns rather than just technology, according to comparative data. This is consistent with Croatia's macro-level example, where e-Schools, which are co-funded by the EU (about €212 million), combine infrastructure, teacher training, and digitalising school administration, resulting in system-wide employability improvements and institutional productivity gains.

New technologies such as AI, blockchain and VR are transforming workplaces and require workers to be more digitally literate and adaptable (Bennett et al., 2017). However, as education systems often fail to meet the demands of the labour market, there is still a persistent skills gap (Cedefop, 2020). It is therefore crucial that programmes are flexible enough to adapt quickly to technological change. In addition to improving labour market outcomes, digital education promotes social inclusion, improves access in remote regions and reduces the digital divide (Zawacki-Richter & Jung 2023). By increasing employability, reskilling and mobility, it contributes to both social cohesion and economic progress.

Overall, the literature clearly shows that while digital transformation and Education 5.0 offer many opportunities to improve learning outcomes, employability and social inclusion, they also bring with them various challenges, such as the

digital divide and skills mismatch. These findings highlight the importance of harmonising higher education with technological and societal changes, which forms the basis of this research.

3. Digitalisation of the education system in Croatia

The digitalisation of the Croatian education system has been an important modernisation process over the last decade. Significant progress has been made in providing broadband internet access and digital equipment in schools, but there are still some challenges, especially in rural areas with uneven infrastructure and equipment (Ministry of Science and Education, 2020). Many schools are equipped with computers, tablets, projectors, smartboards and other digital devices. However, the quality of the equipment varies depending on the location and financial capacities of the schools (UNICEF Croatia, 2021). Digital competencies of students and teachers have improved, but inequalities among schools and the lack of systematic professional development for teachers remain issues (Ministry of Science and Education, 2020). The COVID-19 pandemic accelerated the transition to online teaching but also exposed system vulnerabilities related to technical equipment and preparedness (UNICEF Croatia, 2021). Nonetheless, Croatia demonstrated the ability of quick adaptation, laying the foundations for further development of digital education. (CARNet, 2021).

One of the key strategic documents is the National Development Strategy of the Republic of Croatia until 2030, which places digital transformation of education as a priority, particularly focusing on developing digital competencies across all age groups (Ministry of Science and Education, 2020). The 2014 Strategy for Education, Science and Technology also emphasises the need to modernise the school system through new curricula and the application of ICT technologies. The “School for Life” initiative introduced a strong focus on digital skills and digital content in teaching (Ministry of Science and Education, 2018). The “e-Schools” project provides infrastructure, teacher training, and digital school management (CARNet, 2021). Moreover, Croatia also uses EU programmes such as Erasmus+, Digital Europe, and Horizon Europe to fund digital competency development (European Commission, 2023). However, systematic monitoring of the effects of digital policy and institutional coordination continue to present challenges.

The funding of digitalisation in the Croatian education system relies on national, local, and EU resources that support large-scale modernisation projects (CARNet, 2021). The “e-Schools” project, worth 212 million euros which is primarily financed by the European Regional Development Fund, provided equipment for over 1300 schools, teacher training, and development of digital educational content (CARNet, 2021). It is important to mention that schools can also apply for additional national and EU grants to further improve their digital infrastructure and staff competencies (UNICEF Croatia, 2021). The Croatian Academic and Research Network (CARNet) plays a crucial role in digital transformation by providing infrastructure, training, and technical support to schools. Furthermore, digital literacy is fostered through initiatives such as “e-Laboratory” and “Loomen” (CARNet, 2021). Despite these advancements, only 56% of Croatian citizens have basic digital skills, posing challenges for effective and safe use of digital tools in education (European Commission, 2023). The national digital platform edu.hr offers centralised access to digital resources, online collaboration tools, and continuous professional development for teachers (CARNet, 2021).

The digital maturity of schools in Croatia is assessed through a self-assessment model covering various dimensions, such as infrastructure, digital teaching content, digital literacy of teachers and students, organisational readiness, and digital development strategy (CARNet, 2021). According to data from the second phase of the “e-Schools” project, more than 50% of participating schools reached advanced or highly advanced levels of digital maturity, while the number of schools at the initial level significantly decreased (CARNet, 2021). Schools that achieve a higher level of digital maturity are able not only to use existing tools but also to develop their own digital innovations and design teaching in a way that includes collaborative learning, inquiry-based learning and the development of critical thinking. This is in line with Soller (2001) who argued that support for sophisticated student interactions, such as students challenging one another by posing questions, expressing opinions, and reflecting on their knowledge is necessary for computer supported collaborative learning. However, Collazos et al. (2021) found that digital learning management systems still provide only limited support for learners’ emotions and situational awareness.

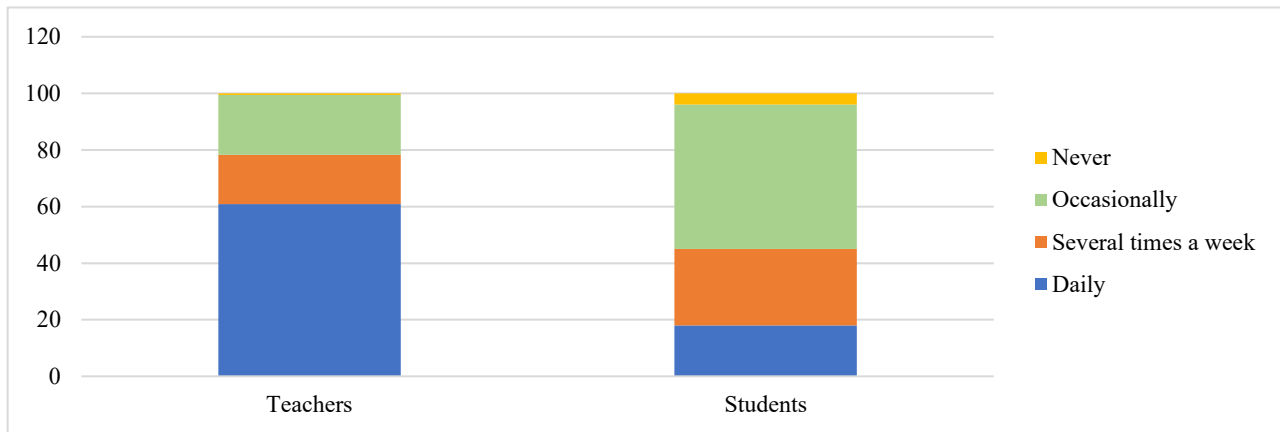
4. Research and findings

To understand the digitalisation in Croatian education system, a survey with 22 questions was conducted among 337 educational staff in the period from 31st March to 24th April 2025. The analysis was focused on the demographic data of the respondents, their perceptions of the availability and use of digital tools, as well as their attitudes towards the impact of technology on education. The main objective was to collect data on the current state of digital technologies in schools, assess the readiness of teachers and students to use digital tools, and identify the challenges they face during the implementation of digital solutions. This survey provided insight into how digitalisation affects the educational process and highlighted key obstacles and opportunities for further development. Most respondents were female (82%), with the largest age group being 36-55 years old. Participants represented all regions of Croatia.

The survey results show that 61% of teachers use digital tools in teaching daily, while 18% use them several times a week. Around 21% of teachers use digital tools occasionally, and less than 1% report never using them. This indicates

that technology is well integrated into the teaching process, and most teachers recognise its value in daily work with students. In contrast, students' use of digital tools for independent learning at home is perceived to be lower. Only 18% of educational staff believe students use digital tools daily, 27% thinks it is done several times a week, 51% said occasionally, and 4% indicated that students never use such tools at home. These results suggest there is room for further encouragement of digital learning outside the classroom, particularly to develop students' independence and digital literacy.

Illustration 1. Use of digital tools: teaching vs. perception of home use

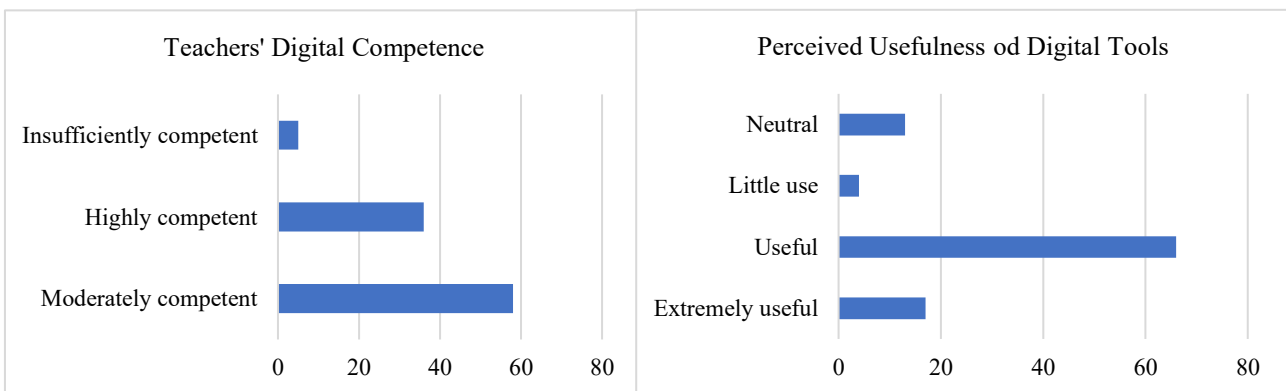


Source: Authors' illustration based on research results

One of the important issues relates to the digital equality of students in different parts of Croatia, and respondents expressed concern about possible spatial differences. Namely, half of the respondents believe that students in urban areas have better access to digital technology, while 40% of them are unsure. These results indicate perceived spatial inequalities and highlight the need for further investment to ensure equitable digitalisation in schools regardless of their geographic location.

Moreover, the survey results indicate that 58% of teachers rate their digital competence as moderate, while 36% consider themselves highly competent in using technology in education. Only 5% feel they are insufficiently competent in this area. These findings suggest a solid level of digital proficiency among teachers but also highlight the need for further training and professional support to ensure confident and effective use of technology to enhance teaching. Further, when inquired about usefulness of digital tools in learning, most respondents expressed a positive view. Out of 337 participants, 66% consider digital tools useful, while 17% rate them as extremely useful. About 13% of them hold a neutral opinion, and only 4% think digital tools are of little use. These results indicate that most teachers recognise the significant potential that digital tools have in learning and teaching, confirming their value in modern education.

Illustration 2. Teachers' evaluation of their digital competence and perception of digital tools usefulness



Source: Authors' illustration based on research results

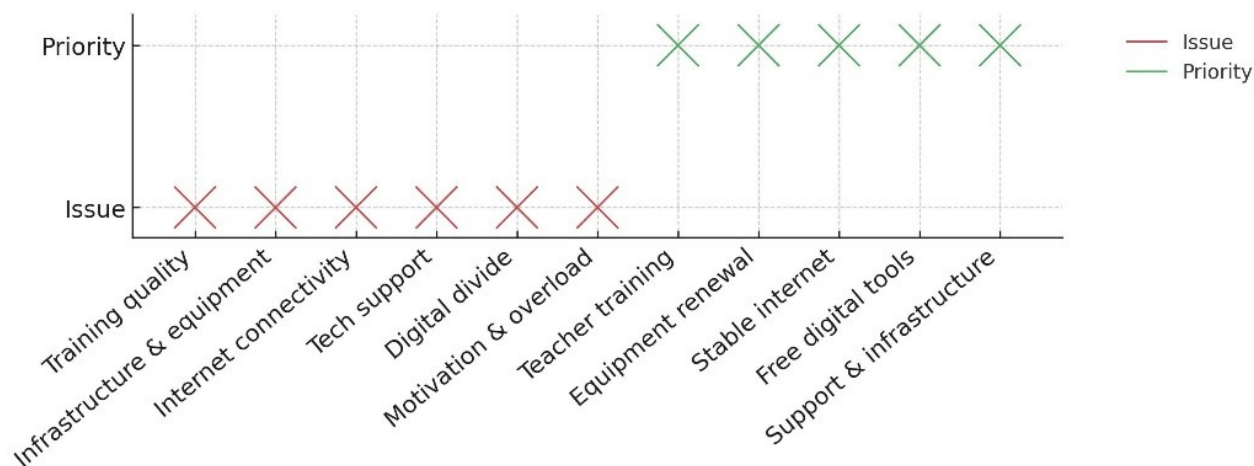
Many respondents believe that digitalisation in education can positively affect the Croatian economy. One of the benefits that has been highlighted is the development of students' skills essential for the modern labour market, such as computer literacy, familiarity with digital tools, information processing, and basic IT skills. These competencies are prerequisites for many 21st-century jobs. Digitally literate students have better employment prospects in sectors such as IT, administration, online business, and other modern services. Moreover, digital materials can replace printed textbooks,

reducing printing and distribution costs. Automation and digital administration speed up and simplify processes. Digital tools facilitate access to education in remote and rural areas and assist students with disabilities or those unable to attend in-person classes. Investment in digital education can boost the growth of the IT industry and innovation, contributing to long-term GDP growth and export potential. On the other hand, some respondents expressed concerns, such as inefficient or superficial use of digital tools, uneven teacher training, and students often using technology for entertainment rather than learning. Concerns also include screen overexposure reducing concentration, memory, and logical thinking; fears that digital tools may dull creativity and motor skills; and the risk that excessive digitalisation might threaten practical skills like handwriting and verbal communication. Digital inequality, reflected in the lack of devices, internet, or family digital skills may widen educational disparities. Technology is only a tool, and without quality curricula, motivation, and professional staff, digitalisation alone cannot ensure progress. Balanced and thoughtful integration with traditional methods is key. Economic benefits depend on effective technology implementation, with quality training for teachers and students being essential. Digital tools should support, not replace, the development of core personal and social skills. While scepticism exists, most responses suggest that digitalisation has the potential to bring long-term economic benefits if implemented wisely, equitably, and with system support. Key prerequisites include equal access, quality teacher training, smart integration of digital and traditional methods, and ongoing monitoring of educational impacts.

Based on respondents' answers, several key aspects of digital education in Croatia clearly stand out as those that need greater financial support. The most frequently mentioned is teacher training, as it is crucial for teachers to be properly equipped to use new digital tools. Many believe that without adequate training, digital equipment will not be utilised to its full potential. Regular and specific training sessions, along with motivation for continuous learning and professional growth, are essential. Equally important is the access to modern tools and licences for digital applications, which are often not free. Upgrading equipment is also highly significant, as outdated computers, tablets, and smart boards often fail to meet the needs of modern teaching methods and tools. Some even suggest that every classroom should have a computer or tablet for every student. Moreover, a stable and fast internet connection is fundamental for successful digital teaching. Many respondents pointed out connectivity issues, especially in rural areas, and emphasised that internet access is a prerequisite for using digital tools. Investing in the expansion and improvement of internet access is key to further digitalisation. It is recommended that more free digital tools are made available to teachers so that they can fully utilise their potential without having to buy expensive premium versions. Differences in the equipment of schools were identified, depending on size, needs and resources. Some schools lack adequate infrastructure for digital teaching, while others are well equipped. Equal access to quality equipment and technology across all schools is urged. Besides teacher training, education for students and parents on safe and smart use of digital tools is necessary. Increasing the number of computer science hours in schools is also recommended to improve students' technological skills. In summary, the responses suggest that the largest investments should focus on teacher education, equipment renewal, stabilising internet connectivity, and providing free digital tools, accompanied by support for school adaptations and infrastructure improvements.

Moreover, several interconnected key problems in the digitalisation of education were identified. A frequent concern is excessive digitalisation, where digital tools become an end in themselves rather than a support for learning. Lack of technical support is a major issue, as many schools lack dedicated personnel for maintaining equipment, and reliance on external collaborators is not a sustainable solution. Teachers often solve technical problems themselves despite lacking training. Furthermore, digital literacy is low among students, parents and especially older teachers, who find it difficult to adapt to new technologies. Besides, training is often superficial, inadequate and repetitive without offering concrete solutions. Many teachers lack motivation and support for continuous learning and the development of digital skills. In addition, administrative overload limits teachers' willingness to use new digital tools. High costs are a significant barrier to the introduction and maintenance of digital devices and licences and hinder balanced development in schools. Equipment is often outdated, of poor quality and prone to failure, and schools lack the funds to replace or repair it. Some equipment cannot be used due to compatibility issues and adding to that poor internet connection results with a further worsen user experience. This is especially the case in rural areas, which further deepens the digital divide. Moreover, digitalisation often has the tendency of widening social inequalities as not all students can afford devices or high-speed internet at home.

Further, some students and teachers demonstrate resistance to digital tools due to insecurity or lack of understanding. Another problem is the lack of information literacy because many students are unable to critically evaluate information. Increasing dependence on digital tools has the capability to reduce students' ability to think, write and concentrate independently, which could potentially affect educational outcomes. Digital teaching cannot replace face-to-face interaction between teachers and students, and over-reliance on technology can affect the quality of relationships in the classroom. A major challenge is the lack of a comprehensive, coherent digital strategy, since the system is not sufficiently adapted to the needs of all schools, and there is lack of uniformity and systematic implementation of digital tools. This points out that effective digitalisation is not a matter of more equipment and machines, it is a matter of properly designed support, training, and involvement of all the stakeholders in education.

Illustration 3. Key barriers and investment priorities

Source: Authors' illustration based on research results

The question of whether a wider introduction of digital tools would improve the quality of education in Croatia generated a wide range of opinions from respondents. Attitudes ranged from enthusiastic support to clear rejection. Many believe that digital tools have the potential to improve education by increasing student motivation, accessibility of information and interactivity in the classroom. Moreover, tools such as quizzes, multimedia content and knowledge-sharing platforms were seen as means to make learning more engaging and effective, especially for the generations that have grown up digitally. The respondents also emphasised the importance of involving students in modern learning forms in order for them to remain competitive in the 21st-century labour market. On the other hand, many respondents cautioned that technology alone is not a magic solution. They pointed to potential negative outcomes, such as reduced fine motor skills, dependency on quick answers without comprehension, and decline in expression and creativity. Digitalisation cannot replace the teacher's role, and education quality depends primarily on teacher competence, pedagogical approaches, and content quality. Digital tools are useful only if they are properly integrated into the teaching process, along with the teacher training, technical support, and equal conditions for all students. Without a systematic approach and clear goals, digitalisation is at risk of becoming superficial and ineffective. While there is a general consensus that digital tools can enrich education, most participants stress moderation, purposeful use, and the human factor. Digitalisation should serve as an aid in the hands of educated and motivated teachers, not an end in itself. True educational quality still remains rooted in knowledge, dedication, and interpersonal relationships within the classroom.

A total of 92.3% of respondents reported having participated in some form of training related to the use of digital tools in education, indicating a high level of engagement and awareness of the importance of digital competence in the educational process. This suggests that teachers and other educational staff are willing to acquire new knowledge to improve their teaching practice and adapt to modern educational demands. Teacher education is particularly important, with demands for practical, concrete, and useful training rather than theoretical lectures or short webinars. Teachers expressed a desire for workshops with active learning and clear classroom applications, as well as recognition and funding of such professional development. Continuous training tailored to real needs, increased availability of free digital tools, and reduced reliance on expensive commercial software were also stressed. There was a recommendation for a unified digital platform that would integrate e-diaries, digital textbooks, learning materials, and communication between schools, students, and parents. A balanced approach was advised to prevent the overshadowing of literacy, handwriting, and creative thinking development by digitalisation. Regarding smartphone use in classrooms, the majority of teachers disagreed with the idea of allowing smartphones during lessons. Many expressed strong opposition or moderate disagreement, and only a small minority supported the idea. Concerns about smartphone use during lessons are prevalent. Most teachers firmly believe that a majority of students would misuse mobile phones if allowed in class, with additional teachers cautiously agreeing. Only a limited number oppose this view, and a few remain neutral.

The majority of teachers agree that integrating digital tools into the classroom can enhance the quality of teaching. While a larger portion of respondents believe that digital tools somewhat improve teaching effectiveness, a smaller yet notable group fully endorses this view. There is also a significant number of neutral responses (31%), indicating some uncertainty, and a minority of teachers who disagree (13%) with this statement. When it comes to the effect of digital tools on students' educational outcomes, opinions vary. Although 36% of respondents adopt a neutral stance, 24% somewhat agree and 18% fully agree that digital tools enhance learning achievements. Taken together, these 42% represent a more substantial share than the neutral group. Therefore, the findings suggest that teachers are more inclined to perceive digital tools as beneficial rather than remaining neutral. However, some educators remain sceptical and either partially or completely

disagree with the idea that digital tools improve student performance. When it comes to the question of whether digital tools are primarily used for entertainment rather than learning, teachers' opinions are also divided. The largest group (33%) was neutral, which shows uncertainty. A significant number agreed that digital tools are used more for entertainment, while the rest stated that these technologies are actually used for educational purposes. This diversity of opinions highlights the ongoing debate about the primary role of digital tools in the educational environment. In summary, while the potential benefits of digital tools for teaching are widely recognised, there remains a notable degree of uncertainty and hesitation among educators. These diverse perspectives emphasise the importance of balanced, well-supported and purposeful integration of technology into the classroom. When asked whether technology has no significant impact on students' academic performance, most educators remained neutral (32%), demonstrating their uncertainty on this issue. The rest were divided between agreement and disagreement, which points to a lack of consensus on the extent to which digital tools influence learning outcomes. Opinions were also divided on the claim that students performed better before the introduction of digital tools in the classroom. Most teachers (38%) again took a neutral stance, indicating that they were indecisive about the validity of this claim. Moreover, 23% of teachers fully agreed that student achievement was better before digital inclusion and 22% somewhat agreed. On the other hand, 9% of respondents claimed that educational results had not improved after digital tools were introduced, while the rest observed no significant change in performance. These findings reflect an ongoing debate about the true impact of digital technologies on education and suggest that the effectiveness of such tools is conditioned upon their integration, pedagogical context, and broader educational strategies.

Finally, the limitation of this study is that the measures are perceptual and cross-sectional, capturing teachers' self-reported practices and views at one point in time. Although home-based digital learning depends on the wider learning environment, the present research focuses on educators and does not include students' or parents' perspectives. In addition, situational awareness within the sample is uneven, e.g., about 40% of respondents were unsure on key items, while roughly half perceived an urban-rural access gap. These factors suggest the need for more comprehensive, multi-source data in future work. However, the original scientific contribution of this paper lies in providing an up-to-date, national overview of digitalisation in Croatian education based on a substantial survey of education staff. By linking classroom-level experiences (tools, training, costs, and outcomes) to system level considerations of employability and economic development, it bridges the micro and macro levels, positioning digitalisation as both an educational and an economic agenda. It also translates global trends in digital transformation into Croatia-specific policy recommendations grounded in reported needs and ongoing national programmes and covering infrastructure, a unified national platform, cybersecurity, continuous professional development, and monitoring. To move beyond perception-driven, cross-sectional data, forthcoming studies should use longitudinal and quasi-experimental designs that track the same educational institutions over time while complementing educator assessments with empirical data. Finally, future research could integrate different perspectives, i.e., include students and parents in addition to educators in order to triangulate findings derived from school settings with those in home learning environment, which according to our findings has significant implications.

5. Discussion

The findings of this study highlight several important aspects of digitalisation of the Croatian education system. While digital tools are generally recognised as useful for improving teaching quality and student motivation, further investment is needed in infrastructure such as stable internet, regular equipment renewal, and reducing inequalities in access to technology, particularly between urban and rural areas. The use of digital tools in education should not be seen as an end in itself but as a means of achieving better learning outcomes, with continuous monitoring of their impact on both students and the teaching process. Teacher training proved to be one of the crucial factors for a successful digital transformation. Respondents repeatedly emphasised that systematic and practical training is a prerequisite for the full use of digital devices. This finding is in line with Holenko Dlab et al. (2025) who argue that for successful implementation of remote education, teachers need to acquire a variety of skills and share the examples of best practices. Teachers are generally willing to adopt new technologies, but they need ongoing, targeted training and institutional support to effectively integrate these tools into classroom practice. These findings are consistent with previous research that emphasises the importance of equitable access and teacher training as a prerequisite for effective digital transformation (OECD, 2018; Selwyn, 2016).

Moreover, while the majority of teachers recognised the benefits of digital tools, they also expressed concerns about excessive digitalisation and its potentially negative impact on the development of key skills such as fine motor skills, creativity and social skills. This points to the importance of a balanced approach in which digital technologies support, but do not replace, face-to-face interaction between teacher and student. Teachers' concerns about excessive digitalisation reflect the broader discussion in the literature, which emphasises that technology should complement rather than replace pedagogy and face-to-face interaction (Bates, 2005; Selwyn, 2016). Because there are so many digital resources available, lecturers will need to give fewer lectures and serve more as resource facilitators while also keeping an eye on actions and outcomes over time (Bygstad et al., 2022). The Croatian experience, particularly through initiatives such as e-schools, shows that progress is possible when infrastructure investment is combined with professional support (CARNet, 2021). At the same time, the focus on broader frameworks such as Education 5.0 emphasises the need not only to integrate

advanced technologies, but also to promote critical thinking, creativity and people-oriented skills (Ahmad et al., 2023; Rubeena & Ansari, 2024).

International evidence shows that approaches to digital transformation vary across systems and levels of education. Recent reviews map case work in Malaysia, Thailand, Mexico, South Africa, Germany, Italy, Sweden, Greece, China, the USA, Australia, Norway and New Zealand, with higher education as the most studied level and engineering/entrepreneurship among the most examined domains (Mukul & Buyukozkan, 2023). Diverse pathways to digital transformation are demonstrated by comparative evidence, such as open-innovation labs in Mexico that are promoting Education 4.0 (Miranda et al., 2019), Malaysian students' high demand for digital learning platforms (Bujang et al., 2020), Italian entrepreneurship education labs (Secundo et al., 2020), and Norway and New Zealand's different national implementation strategies (Madsen et al., 2018). Taken together, these cases indicate that policy coordination and institutional capacity are the main differentiators of progress, more than any single technology choice. In this context, Croatia's national programs like e-Schools reflect the emphasis on capacity-building seen globally, and inequalities in infrastructure and teacher professional development follow trends seen in other systems with a mid-level of digital maturity.

Overall, the findings suggest that digital transformation in Croatian education has significant potential, but its success depends on a comprehensive approach that combines adequate infrastructure, high-quality teacher training, equitable access and strong institutional support. Only through such an integrated strategy can digitalisation truly serve as a tool for improving the education system and creating broader social and economic benefits.

6. Recommendations for improvement

The digitalisation of the Croatian education system represents a necessary step towards modernisation and balance between traditional and digital approaches to learning. Although significant progress has been made, further action is needed to ensure that all students and teachers have equal opportunities for quality education. The results of this study point to several key areas for improvement.

Firstly, investment in infrastructure remains essential. Reliable high-speed internet and modern equipment are prerequisites for effective digital education. Particular attention should be paid to reducing the disparities between urban and rural schools through targeted funding and public-private partnerships. In addition to connectivity, the renewal and standardisation of equipment is also necessary to provide students and teachers with modern devices such as computers, tablets and smartboards. Additionally, each school should have a sufficient number of devices. Equal access to modern technology would enable greater personalisation and inclusion in learning. Another important recommendation is the development of a standardised national digital platform. Currently, different systems and tools are used in schools, which often leads to fragmentation. A single, user-friendly platform that integrates schedules, teaching materials, assignments, communication, assessment and administrative functions would improve efficiency, reduce duplication and provide teachers, students and parents with a transparent overview of student progress, while ensuring alignment with the national curriculum.

Teacher training is also a key component of a successful digital transformation. Professional development should be continuous and practice-orientated, combining technical skills with pedagogical strategies for the effective use of digital tools. Workshops, online courses and school-based mentoring programmes could help teachers acquire not only technical skills, but also methodological approaches for integrating digital tools into the classroom in order to ensure that technology fosters engagement, creativity and critical thinking. Training should be organised in line with the requirements of teachers with different digital skills and should cover elements of data literacy, online safety and digital citizenship. In addition to teacher training, the education system must also address the issue of cyber security and data protection through the installation of robust protection systems, while at the same time raising awareness among teachers, students and parents of safe online practices.

A balanced teaching model is also important for achieving optimal learning outcomes. Digital tools should not be considered as a replacement for traditional methods, but rather as a selective support when they really encourage understanding or the development of new skills. Lesson planning should be based on clear objectives and activities that require practical work, manual skills or verbal discussion, and priority should be given to hands-on tasks, group discussions and workshops without screens. Yet, when explaining complex processes such as chemical reactions, geographical changes or mathematical models, the use of virtual labs, interactive presentations and pedagogical applications can significantly increase engagement and facilitate the visualisation of abstract concepts. In practice, this means that teachers should design lessons that alternate between analogue and digital activities. For example, after students have created a sketch by hand or solved tasks on paper, they can transfer their work to a digital form, analyse mistakes together or extend their ideas by searching for additional online resources. Such a hybrid environment would encourage the development of fine motor skills and concentration through handwriting while strengthening digital skills through navigation and information analysis. This way, students reap the benefits of both traditional and digital approaches, while teachers retain control over the dynamics of the lesson and the choice of the most effective tool for each part of the curriculum.

In this context, it is particularly important to integrate digital literacy into the curriculum. Besides technical skills, digital literacy must also include the ability to critically assess online information, protect personal data and use technology in an ethical and responsible way.

Finally, greater involvement of parents in the digitalisation process would strengthen the connection between schools and families. Workshops and online resources could help parents to better understand how digital tools can support learning and how they can guide their children to use technology at home in a safe and meaningful way. Sustainability could be ensured through systematic monitoring and evaluation mechanisms should be established in order to track the effects of digitalisation on infrastructure, teaching quality, student outcomes and teacher satisfaction. This would allow for continuous improvement and adaptation of strategies.

All of these proposals emphasise that successful digital transformation is not solely about technical resources. It relies on systematic support, comprehensive teacher training, active engagement of all stakeholders and a balance integration of technology into pedagogy. With a coordinated strategy, digitalisation can foster equity, enable innovation and enhance the overall quality of the Croatian education system.

7. Conclusion

The digitalisation of Croatian education has gained increasing strategic importance in recent years, as it has emerged as a key factor in shaping the future of the education system, economy and labour market in the modern knowledge society. In this study, multiple aspects of digitalisation were explored, starting from the historical evolution of technology in education, through economic effects and labour market demands, to specific challenges and opportunities in the Croatian context. The results clearly point to the fact that the digital transformation of education is not only a matter of technology, but also a matter of adapting teaching methods, and strengthening the competencies of all participants. Moreover, it is also a matter of strategic and responsible change management. The evolution of digital technologies indicates that educational systems can no longer function without the integration of ICT tools. E-learning, virtual classrooms, digital textbooks and interactive platforms are no longer just an addition to traditional education, but are becoming its essential part, especially in the context of global crises such as the COVID-19 pandemic. Digital tools enable greater flexibility, personalisation and accessibility of education, while at the same time requiring new knowledge and skills, responsible data and content management, as well as continuous adaptation of teaching methods.

The economic dimension of digitalisation is equally significant. Quality digital education contributes to productivity growth, innovation, and employability. It is also directly linked to lifelong learning and the need to prepare students for professions that are yet to emerge, while adapting to quick technological change. In this respect, education plays a crucial role not only in addressing current labour market needs but also in equipping young people for the jobs of the future.

The Croatian case demonstrates that while substantial progress has been made through initiatives such as the “e-Schools” project, CARNET activities, the edu.hr platform, and digital maturity assessments, important challenges still remain. These challenges include disparities in equipment, unequal digital competences among teachers, and inconsistent access to training and digital content. The survey results further confirm this, while many teachers actively use digital tools and recognise their benefits, others point to obstacles such as insufficient training, administrative burden and limited institutional support.

The results also demonstrate the importance of parental involvement, because without their support, digital learning at home loses its effectiveness. Based on these findings, several recommendations were made, such as systematic and continuous teacher training, a modern and equitable infrastructure, greater parental involvement and stronger institutional support. The development of a standardised national platform, strong cybersecurity measures and systematic monitoring mechanisms are also necessary to ensure the effective implementation and sustainability.

Finally, the digitalisation of education in Croatia should not remain fragmented or implemented through individual projects. A coordinated national vision that would bring together policy makers, schools, teachers, students and parents is essential. Such a vision must ensure a balance between technology and pedagogy, ensure equal access to quality education regardless of location or socio-economic background and create the conditions for long-term sustainability. If implemented properly, digitalisation has the potential not only to modernise the Croatian education system, but also to make it more equitable, effective and fully focused on the needs of 21st century learners.

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