Distance teacher training in ICT: from a technocentric approach to teaching innovation

ABSTRACT

The training of teachers in Communication and Information Technologies (ICT) is a basic prerequisite for upgrading the quality of education. In the international literature, reference is often made to the process of transition from a technocentric approach, which aims at the acquisition of technical skills, to a more oriented pedagogical perspective, which utilizes new technologies as a means to transform learning and shape teaching innovations. Through the bibliographic analysis, the effects of distance training programs on teachers, teaching, teaching innovation, and in general on the strengthening of the learning process are presented. This study constitutes a systematic qualitative literature review that attempts to highlight the need for training programs that combine theory with practice, promote modern teaching methods and techniques, utilize the experiences and experiences of teachers, while at the same time satisfying their real needs. Through a critical narrative review of international literature (1995–2025), the present study identifies consistent evidence that insist distance ICT training enhances teachers' self-efficacy and pedagogical use of technology, while also revealing a persistent gap between technical training and pedagogical transformation.Particular emphasis is placed on collaborative practices, educational design that creatively utilizes ICT, but also on cultivating a critical attitude towards technology. After all, the transition from a technocentricto a pedagogical model of training requires both the acquisition of knowledge and skills, as well as a change of philosophy that leads to more creative and meaningful forms of learning for students and teachers.

KEY WORDS: ICT, training, learning, teaching innovation.

INTRODUCTION

Information and Communication Technologies are particularly important and affect key aspects of economic and social life, such as teaching and education in general, making it necessary for teachers to become familiar with technology. Living in a digitalized era, the integration of digital technologies in course teaching is essential more than ever (Lawrence & Tar, 2018). Today's students use digital tools and apps every day for their entertainment and information, so it becomes essential for them to develop computational and critical thinking skills (Waterson & Milmo, 2021). Nevertheless, teachers due to lack of familiarity (Hussin, 2018), but also the ability to design the lesson, based on ICT (McDonald, 2017; Rich et al., 2021), are particularly hesitant to integrate new technologies into their teaching. In this regard, students' preparation for the digital age depends on teachers as key agents of changing attitudes, skills, and behaviors (Tan et al., 2017).

Distance teacher training in Information and Communication Technologies has been shown to improve both the quality of the learning process and the professional development of teachers. Leveraging technological innovations, such as synchronous (Webex, Teams, etc.) and asynchronous education (Moodle) platforms, digital software, interactive whiteboards and educational simulations, virtual and augmented reality, artificial intelligence, can offer interactive learning experiences that enhance students' understanding and engagement ((Johnson & Johnson, 2020; Li, Sun, & Zhang, 2022), on the other hand, however, require familiarization and effective use on the part of teachers (Paxinou, 2021). For this reason, the distance training of the human resources of education (e.g. B1 & B2 level of ICT) must offer modern technological experiences, so that teachers can transfer them to their classrooms (Voogt et al., 2013).

Despite the existing and growing body of research on ICT-based teacher training, the literature remains fragmented, because, while several studies emphasize technical skill acquisition, there are fewer that critically examine the pedagogical depth and the

transformative impact of distance training programs. So, this review addresses this gap by critically synthesizing evidence on the shift from technocentric to pedagogically driven ICT professional development.

METHODOLOGY

The present study adopted a literature-based research methodology aiming to highlight the significance of distance professional development in new technologies, instructional innovation, and, by extension, in teaching practice. The research design was grounded in a systematic qualitative content analysis. A rigorous and systematic search strategy was implemented across academic and educational databases such as Google Scholar, Scopus, and ERIC (Education Resources Information Center), which provided access to recent interdisciplinary studies combining educational theory, professional training program design, psychology, and digital education.

In addition, national sources were utilized, including the National Documentation Centre (EKT), institutional repositories of Greek universities, and Greek open-access scientific journals such as the Athens Journal of Education, the Journal of Contemporary Education Theory & Research, Adult Education, and Research and Technological Development, in order to collect relevant literature.

To ensure validity, clear inclusion and exclusion criteria were applied. The inclusion criteria comprised peer-reviewed scientific articles, empirical studies, theoretical investigations, and policy reports published between 1995 and 2025. Only studies focusing on distance education, teaching, instructional innovation, factors influencing teachers' professional development, and educational design were considered. Particular emphasis was placed on works offering comparative analyses or studies with a specific focus on the Greek context. Sources that were not peer-reviewed, lacked full-text availability, or were not directly related to the topic of distance teacher professional development were excluded.

The studies that were selected were analysed through thematic qualitative synthesis, and were focusing on recurring patterns, which are related to pedagogical orientation, teachers' professional identity, and, lastly, instructional innovation. Particular attention was paid to contradictions, methodological limitations, and, also, to contextual differences across studies

THE INTEGRATION OF ICT IN EDUCATION

With the gradual integration of new technologies in education, the role of the teacher focused on the design of the lesson and activities based on educational software and digital applications, adapted to the needs of children. At the same time, the role of the student has changed, who is no longer a passive receiver of information, but assumes an active role and responsibility for his education. This development has opened up and continues to open up new perspectives for the educational community, but also for the formation of a modern, dynamic and inclusive educational environment (Selwyn 2023). In this context, children, as future citizens, acquire new competences and skills, useful throughout their lives, contributing to the change of working conditions and the progress of society in general (European Commission, 2018).

The utilization of technologies, such as digital learning platforms, allowed the distribution, organization and management of educational materials (Bond, et al., 2021), collaborative tools, such as Google Slides, Google Classroom and Microsoft Teams, facilitated collaboration between both students and teachers, enabling document sharing, synchronous and asynchronous discussions, but also real-time collaboration (Moorhouse, 2021). Also, the use of modern and smart devices (smartphones, mobile phones and mobile devices) facilitated children's access to educational material, but also the completion of tasks and activities, without spatiotemporal constraints (Park, 2021). After all, in the context of the educational community, ICTs are often referred to as innovative technologies, which enhance collaboration, adaptation and interactivity of the learning process (OECD, 2021).

In recent years, the integration of virtual and augmented reality applications into the teaching (Papadakis &Kalogiannakis, 2020), machine learning through artificial intelligence and educational robotics, have shaped new personalized educational experiences and modern dynamic learning environments, while at the same time creating new perspectives in the teaching of courses (Karsenti&Bugmann, 2019).At the same time, teachers were facilitated in creating learning and practice communities, through which they share experiences, best practices, but also mutual support in matters of cognitive and pedagogical content.

Finally, the integration of ICT in education has enabled human resources to continuously train and cultivate their digital skills, through online programs and seminars, online courses, but also other forms of e-learning, adapted to their needs (Vander Ark et al., 2020), allowing teachers to be fully informed both about their subject matter, and technological developments (Darling-Hammond, Hyler, & Gardner, 2020). Research conducted by Bruntha et al. (2024) highlighted that online trainings and digital tools facilitate faster and more efficient access to knowledge, promote collaborative learning, and support personalized teaching methods, enhancing teachers' work.

In general, the integration of new technologies in teaching and education in general includes on the one hand the technological framework, and on the other hand the educational application of digital tools, with the aim of improving the quality of teaching provided to students (Tzimogiannis, 2019; Naresh, 2020). Based on the above, it is worth noting that lifelong distance learning in ICT, as well as the integration of digital technologies into the learning process, is a complex and multifaceted process, which is due on the one hand to the dynamic nature of the development of technology and, additionally, to the will for professional development of human resources.

EDUCATORS AND NEW TECHNOLOGIES

The characteristics of the human resources of education affect the use of new technologies in the learning process. In particular, gender and age (Guillén-Gámez& Mayorga-Fernández, 2020), teaching experience (Hsu, 2017), and the subject of teaching (Lawrence & Tar, 2018), contribute decisively to the integration of ICT into the teaching of subjects. At the same time, teachers' perceptions and beliefs (Drossel et al., 2017; Okagbue et al., 2023), their willingness and willpower (De Brabander & Glastra, 2021; Farjon et al., 2019), their self-efficacy in the use of new technologies (Ifinedo et al., 2020; Spiteri & Chang Rundgren, 2020), are variables that also influence the adoption of technology as a teaching tool. Conversely, negative emotions, such as fear, anxiety, and distrust towards digital applications, are barriers to their integration into educational practice (Tomczyk et al., 2021).

Many teachers accept the usefulness of new technologies in education, as a factor in enhancing students' active participation, but also as an element of educational innovation and enhancing learning (Arancibia et al., 2020; Cheng et al., 2021; Almerich et al., 2023). Also, when the teacher works in a school environment that favors the use of new technologies and in a school where the administration is possessed by the culture of technological innovation, he is much more likely to show a favorable attitude towards the integration of digital tools in his teaching (Spiteri & Chang Rundgren, 2020; Eickelmann, 2011; Lomos et al., 2023). Professional collaboration between teachers, as well as teacher-student relationships in relation to the use of digital tools in learning, are important variables in terms of their use in the learning process (Lomos et al., 2023; Xu et al., 2023). Most teachers recognize the positive contribution of ICT to education, as it provides opportunities for individualized and self-regulated learning (Kamal &Illiyan, 2021; Salas-Rueda et al., 2022), improves the quality of teaching, enhances children's motivation and participation, and student-teacher collaboration.

Therefore, the continuous training of the human resources of education and the methodical technological and pedagogical support are key factors for the use of ICT in teaching practice.

Especially nowadays, where the teacher has the possibility of distance education and training in new technologies, there is an urgent need to formulate modern and up-to-date programs in ICT, adapted to the needs and interests of teachers.

DISTANCE TRAINING OF TEACHERS IN ICT

Lifelong learning aims on the one hand at the personal and professional development of the individual and on the other hand at his adaptation to the continuous changes and increasing demands of modern society (Knapper & Cropley, 2000). In particular, distance education of teachers in ICT leads to the acquisition of specialized knowledge and skills, which are related to both general and technical and vocational education. Therefore, lifelong learning combined with distance learning in new technologies are two key pillars in the development and professional development of teachers, while contributing to their integration into the learning process (Belay et al., 2020; Tomczyk et al., 2021; Baharuddin et al., 2024).

The creation of certified distance learning programs, adapted to the needs and interests of teachers, flexibility and the ability to choose subjects, the provision of financial incentives and continuous technical and psychological support are some of the prerequisites for the success of relevant trainings (Brookfield, 2019). At the same time, the use in training of modern digital tools and teaching methodologies, examples and practical application of the concepts and applications to be taught, the updated and targeted educational material, as well as the pedagogical approach of the technocentricperception of ICT, are factors that can lead a training to achieve its goals.

The training and professional guidance by experienced and digitally competent trainers and the utilization of modern technological applications during the training (electronic classrooms, digital platforms, etc.), provides targeted and immediate feedback, facilitates access to digital educational material, cultivates interaction between trainees and generally forms a flexible and interactive learning environment. In this way, a holistic and inclusive educational

framework is formed, which includes all those elements that can make a training useful, functional and usable in teaching practice.

Although there are several studies that report positive outcomes of online ICT training, other research should also be mentioned that highlight that such programs often prioritize efficiency over pedagogical depth, resulting, in this way, in limited instructional transformation (Valverde-Berrocoso et al., 2021; Avidov-Ungar & Forkosh-Baruch, 2018).According to Biko (1995), it is not enough to participate in a training program for the integration of new technologies into the educational process, but rather the willingness of teachers to revise traditional teaching methods and techniques.

Based on the above, the success of a distance learning ICT training program, but also their effective integration into the learning process, does not depend only on the technological infrastructure and support, the resolution of the obstacles that arise, but primarily on the desire and willingness of teachers to adapt to modern teaching practices. With the appropriate planning and the continuous support of the professional development of the human resources of education, new technologies can be modern tools for learning and strengthening teaching innovation.

STRENGTHENING TEACHING INNOVATION

Training in ICT and the teaching use of new technologies does not inevitably lead to teaching innovation. Preparation, didactic planning, proper assessment of available resources and infrastructure, targeted activities, but above all will and patience on the part of the teacher are required. For this reason, a continuous effort is needed from all educational institutions to convince the teacher of the value of integrating digital tools into teaching, as through innovative practices and methods the quality of the education provided will be improved.

On the other hand, the use of digital games and simulations in teaching is an innovative approach, as it enables children to explore new concepts and apply their knowledge in

realistic scenarios, enhancing their critical thinking and analysis skills (Lu, Wang, & Huang, 2022). Learning Management Systems (LMS) facilitate the creation of personalized courses, which tailor the content of the teaching to the needs and interests of each student.

At the same time, collaborative applications, such as Canva, Google Slides, Padlet, etc., as well as platforms (Google Classroom, Microsoft Teams, etc.), enhance collaborative learning, communication, collective knowledge and teamwork (Bond et al., 2021). Also, new technologies enhance innovation by offering and enhancing online learning, which in combination with face-to-face (blended learning) proves to be particularly effective in assimilating knowledge and engaging learners (Kintu, Zhu, &Kagambe, 2017).

Teaching and innovation is enhanced when teachers, through training, have the opportunity to leverage innovative technologies, such as simulation, augmented and virtual reality, which create flexible, interactive and experiential learning environments. Children experience lifelike activities that enhance active participation, but also the understanding of difficult theoretical concepts (Merchant et al., 2020). Additionally, the use of technologies such as artificial intelligence (AI) and machine learning (ML) can provide personalized learning experiences and promote students' creative thinking (Holmes et al., 2019).

Table 1. Strengthening Teaching Innovation through ICT Training

Dimension	**Key points (keywords)**
ICT training & innovation	not automatic • pedagogical planning • lesson design • resource assessment • teacher commitment
Digital games & simulations	experiential learning • real-world scenarios • critical thinking • problem-solving
Learning Management Systems (LMS)	personalization • adaptive content • learner-centred design
Collaborative tools & platforms	collaboration • communication • teamwork • shared knowledge
Blended learning	online + face-to-face • engagement • flexible learning
Immersive technologies (VR/AR)	interactivity • experiential environments • conceptual understanding
Artificial intelligence & ML	personalized learning • creativity • adaptive feedback
Role of teacher training	attitudes • self-efficacy • pedagogical competence • innovation readiness

From the above, the relationship between training and teaching innovation is understood, as the perceptions, attitudes, abilities and skills acquired by teachers in an ICT training program, leads to the creation of modern teaching approaches and the use of appropriate digital applications and tools, creating attractive learning environments (Arnab et al., 2019). Therefore, a pedagogically and technologically familiar teacher has the ability to create innovative teaching actions, to improve his teaching for the benefit of the quality of education and the learning experience of the trainees.

DISCUSSION

The present study sought to critically examine distance teacher training in Information and Communication Technologies (ICT), with particular emphasis on the transition from a technocentric model of professional development to a pedagogically oriented framework that promotes teaching innovation. Through a systematic qualitative review of international literature spanning three decades (1995–2025), the findings highlight both the potential and the limitations of distance ICT training in transforming teaching practices.

A consistent finding across the reviewed studies is that distance ICT training contributes positively to teachers' digital competence, self-efficacy, and confidence in using technological tools. These outcomes are in line with prior research indicating that online professional development enhances teachers' familiarity with digital environments and increases their willingness to integrate ICT into classroom practice. However, the analysis also confirms a persistent and critical gap between the acquisition of technical skills and meaningful pedagogical transformation. While teachers often develop operational proficiency in digital tools, this does not automatically translate into innovative instructional design or student-centered pedagogical change.

This contradiction reinforces the argument that technocentric training models—those primarily focused on tools, platforms, and software—remain dominant in many distance education programs. Such models tend to reproduce traditional teacher-centered practices in digital form, rather than fostering new teaching philosophies, roles, and learning dynamics. The literature reviewed suggests that without explicit emphasis on pedagogical design, reflective practice, and instructional innovation, ICT training risks becoming instrumental rather than transformative.

Another significant insight emerging from this review concerns the role of teachers' beliefs, attitudes, and professional identity in shaping the outcomes of distance training. The effectiveness of ICT professional development appears strongly mediated by teachers' willingness to reconsider established teaching practices, engage in experimentation, and adopt learner-centered approaches. Factors such as fear of technology, lack of time, limited institutional support, and unequal access to infrastructure continue to function as barriers, even when training opportunities are available. This finding aligns with research emphasizing that technological integration is as much a cultural and psychological process as it is a technical one.

Furthermore, the analysis highlights the importance of collaborative learning and communities of practice in distance ICT training. Programs that encourage interaction, peer exchange, and shared reflection tend to support deeper pedagogical engagement and more sustainable innovation. Collaborative environments allow teachers to contextualize ICT use within their own teaching realities, exchange best practices, and collectively negotiate new professional meanings. In contrast, isolated and content-heavy online courses often fail to support long-term instructional change.

The review also underscores the growing significance of emerging technologies—such as artificial intelligence, virtual and augmented reality, and adaptive learning systems—as potential catalysts for teaching innovation. Nevertheless, the literature cautions that these

technologies only enhance learning when embedded within coherent pedagogical frameworks. Innovation, therefore, should not be understood as the mere adoption of advanced tools, but as a shift in teaching logic, learning activities, and teacher–student interactions.

Despite its contributions, this study is not without limitations. The heterogeneity of the reviewed studies, differences in methodological approaches, and the lack of common indicators for measuring pedagogical innovation constrain the comparability of findings. Additionally, much of the existing literature relies on self-reported data, which may overestimate the actual impact of ICT training on classroom practice. These limitations point to the need for future research employing longitudinal designs, mixed-method approaches, and classroom-based evidence to better capture the transfer of training outcomes into authentic educational settings.

In conclusion, the discussion of the findings confirms that distance teacher training in ICT holds substantial potential for enhancing professional development and supporting teaching innovation. However, this potential can only be realized when training programs move beyond technocentric approaches and systematically integrate pedagogical theory, reflective practice, collaboration, and sustained support. The transition from technology use to pedagogical transformation emerges as a complex, multidimensional process that requires not only skills and infrastructure, but also a fundamental change in educational philosophy and teaching culture.

CONCLUSION

The integration of new technologies into the educational process and the strengthening of teaching innovation requires the formation of a series of factors. First of all, the continuous education and training of teachers in ICT is a sine qua non for cultivating a positive attitude towards the use of digital tools in teaching. The continuous support and provision of educational opportunities to all teachers, without spatio-temporal constraints, for their

technological familiarization and the development of their skills, leads them to stay informed about the latest developments in technology (Koehler & Mishra, 2009).

Teaching innovation cannot be created without adapting teaching to the needs and interests of each student. The use of digital applications, particularly artificial intelligence, can help the educator adapt their teaching, shape inclusive and flexible learning environments, and provide personalized educational experiences (Luckin et al., 2021). They also promote collaboration, communication and interaction, collective and team atmosphere, creating a more supportive learning environment (Johnson, & Smith, 2024).

At the same time, in a distance learning program, continuous technical support and the upgrading of technological infrastructure helps teachers to deal with the technical problems that arise when using digital applications, strengthening their confidence in ICT. Fast and efficient technical assistance, from the specialized technical manager of the program, reduces the stress and anxiety of teachers and strengthens their confidence in the use of technologies when teaching their lesson. Continuous evaluation and improvement of teaching practice ensures the development and upgrading of the course, ensuring in the best possible way the strengthening of the educational process (Xu, & Zhu, 2023).

In conclusion, new technologies have a significant impact on both the training of teachers and the strengthening of teaching innovations in their teaching, as they offer modern tools and opportunities for their professional development and consequently in the improvement of the learning process. Continuous support, training and adaptation to ICT on the one hand limits the number of teachers who are reluctant to use them and on the other hand strengthens the will and willingness of those who really believe that it will strengthen their role, but also the quality of their teaching.The literature review that was carried out, ultimately, demonstrates with arguments that distance education of teachers in ICT can systematically contribute to the enhancement of digital self-efficacy as well as technological competence, while it can, at the same time, support the improvement of the learning process. However, it should be mentioned

that the literature highlights a persistent contradiction, which concerns the fact that the acquisition of technical skills does not automatically lead to pedagogical transformation nor to substantial teaching innovation. Many programs that exist remain technocentric, limited to the use of digital tools to reproduce traditional practices, without, therefore, a profound change in instructional design, as well as in teacher-student roles and in the learning experience.

The critical synthesis of the findings, which was attempted, shows that the success of distance learning requires the systematic connection of theory and practice, the emphasis on pedagogical design, the cultivation of communities of practice, continuous feedback and, of course, substantial technical support. At the same time, significant obstacles emerge, such as, for example, technocentric design, limited time, stress or even mistrust of teachers and inequalities in infrastructure. Therefore, teaching innovation can be defined as a change in teaching logic and learning activities. Finally, the review highlights limitations related to the heterogeneity of studies and the lack of common indicators for evaluating innovation, highlighting the need for future research with long-term data, comparative approaches and, lastly, a focus on the transfer of training results to educational practice.

REFERENCES

Americh, G., Gargallo-Jaquotot, P. A., & Suárez-Rodríguez, J. (2023). Relational structure of the use of technological resources and the pedagogical beliefs of Primary Education and Secondary Education teachers. Personal and contextual factors. *EstudiosSobreEducación, 45*, 51–73. https://doi.org/10.15581/004.45.003

Ancibia, M. L., Cabero, J., & Marín, V. (2020). Beliefs on teaching and the use of information and communication technologies (ICT) by higher education professors. *FormaciónUniversitaria, 13*(3), 89–100. https://doi.org/10.4067/S0718-50062020000300089

Arnab, S., Lim, T., Carvalho, M. B., Bellotti, F., de Freitas, S., Louchart, S., & De Gloria, A. (2019). Mapping learning and game mechanics for serious games analysis. *British Journal of Educational Technology, 46*(2), 391–411. https://doi.org/10.1111/bjet.12508

Avidov-Ungar, O., & Forkosh-Baruch, A. (2018). Professional identity of teacher educators in the digital era in light of demands of pedagogical innovation. *Teaching and Teacher Education, 73*, 183–191. https://doi.org/10.1016/j.tate.2018.03.017

Aziz Hussin, A. (2018). Education 4.0 made simple: Ideas for teaching. *International Journal of Education and Literacy Studies, 6*(3), 92–98. https://doi.org/10.7575/aiac.ijels.v.6n.3p.92

Baharuddin, F. R., Amiruddin, A., Nurlaela, N., &Setialaksana, W. (2024). Teacher growth mindset and ICT integration in Indonesian classrooms: Insights from in-service and preservice teacher programs. *Quality Assurance in Education, 32*(2), 197–212. https://doi.org/10.1108/QAE-08-2023-0136

Berhe, M. T., Khatete, D. D. W., & Mugo, D. B. C. (2020). Teachers' attitude towards integrating ICT in classroom instruction in teaching and learning biology in secondary schools in the Southern region, Eritrea. *Journal of Education and Practice, 4*(1), 56–72. https://doi.org/10.47941/jep.393

Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O., &Kerres, M. (2021). Mapping research in student engagement and educational technology in higher education: A systematic evidence map. *International Journal of Educational Technology in Higher Education, 18*(1), Article 2. https://doi.org/10.1186/s41239-020-00239-6

Brookfield, S. D. (2019). *Understanding and facilitating adult learning: A comprehensive analysis of principles and effective practices*. McGraw-Hill Education

Brintha, P., Subaithani, S., & Shabana, S. (2024). Effectiveness of ICT tools in education. In *Proceedings of the Perspective of ICT Tools in Education* (pp. 91–95). NGM College, Pollachi, India. https://www.scribd.com/document/755169705/Effectiveness-of-i-Ct-Tools-in-Education

Cheng, S. L., Chen, S. B., & Chang, J. C. (2021). Examining the multiplicative relationships between teachers' competence, value and pedagogical belief about technology integration. *British Journal of Educational Technology, 52*(2), 734–750. https://doi.org/10.1111/bjet.13052

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2020). *Effective teacher professional development.* Learning Policy Institute

De Brabander, C. J., & Glastra, F. J. (2021). *The unified model of task-specific motivation and teachers' motivation to learn about teaching and learning supportive modes of ICT use. Frontline Learning Research, 9*(4), 44–60. https://doi.org/10.14786/flr.v9i4.742

Drossel, K., Eickelmann, B., & Gerick, J. (2017). Predictors of teachers' use of ICT in school – the relevance of school characteristics, teachers' attitudes and teacher collaboration. *Education and Information Technologies, 22*(2), 551–573. https://doi.org/10.1007/s10639-016-9476-y

Eickelmann, B. (2011). Supportive and hindering factors to a sustainable implementation of ICT in schools. *Journal of Educational Research Online, 3*, 75–103. https://doi.org/10.25656/01:4683

European Commission. (2018). *Digital competences and technology in education.* https://ec.europa.eu/education/policy/strategic-framework/education-technology_el

Fraillon, D., Smits, A., & Voogt, J. (2019). Technology integration of pre-service teachers explained by attitudes and beliefs, competency, access, and experience. *Computers & Education, 130*, 81–93. https://doi.org/10.1016/j.compedu.2018.11.010

Guillén-Gámez, F. D., & Mayorga-Fernández, M. J. (2020). Identification of variables that predict teachers' attitudes toward ICT in higher education for teaching and research: A study with regression. *Sustainability, 12*(4), 1312. https://doi.org/10.3390/su12041312

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign. https://www.curriculumredesign.org/ai-in-education

402 Ifedo, E., Rikala, J., & Hämäläinen, T. (2020). Factors affecting Nigerian teacher educators'
403 technology integration: Considering characteristics, knowledge constructs, ICT practices and
404 beliefs. *Computers & Education, 146*, 103760.
405 https://doi.org/10.1016/j.compedu.2019.103760
406 Johnson, D., & Johnson, R. (2020). What is cooperative learning? Cooperative Learning Institute.
407 http://www.co-operation.org/what-is-cooperative-learning
408 Johnson, A., & Smith, B. (2024). The impact of emerging technologies on teaching and learning.
409 *International Journal of Educational Research, 35*(2), 123–137.
410 Kamal, T., &Illiyan, A. (2021). School teachers' perception and challenges towards online teaching
411 during COVID-19 pandemic in India: An econometric analysis. *Asian Association of Open*
412 *Universities Journal, 16*(3), 311–325. https://doi.org/10.1108/AAOUJ-10-2021-0122
413 Karsenti, T., &Bugmann, J. (2019). What about robotics and artificial intelligence in education?
414 Some exploratory views. In T. Karsenti& L. Collin (Eds.), *The EdTeKo Project: Teaching,*
415 *Learning and Technology* (pp. 3–18). Springer. https://doi.org/10.1007/978-3-030-23549-1_1
416 Kintu, M. J., Zhu, C., &Kagambe, E. (2017). Blended learning effectiveness: the relationship
417 between student characteristics, design features and outcomes. *International Journal of*
418 *Educational Technology in Higher Education, 14*(1), Article 7.
419 https://doi.org/10.1186/s41239-017-0043-4
420 Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?
421 *Contemporary Issues in Technology and Teacher Education, 9*(1), 60–70.
422 https://citejournal.org/volume-9/issue-1-09/general/what-is-technological-pedagogical-
423 content-knowledge-tpack
424 Knapper, C., & Cropley, A. (2000). *Lifelong learning in higher education* (3rd ed.). Taylor and
425 Francis Routledge.

Lawrence, J. E., & Tar, U. A. (2018). Factors that influence teachers' adoption and integration of ICT in teaching/learning process. *Educational Media International, 55*(1), 79–105. https://doi.org/10.1080/09523987.2018.1439712

Li, J., Sun, Y., & Zhang, W. (2022). The effect of augmented reality on learning performance and satisfaction: A meta-analysis. *Interactive Learning Environments, 30*(2), 201–218. https://doi.org/10.1080/10494820.2019.1674882

Lim, C., Luyten, J. W., & Tieck, S. (2023). Implementing ICT in classroom practice: What else matters besides the ICT infrastructure? *Large-Scale Assessment in Education, 11*(1), 1–28. https://doi.org/10.1186/s40536-022-00144-6

Liu, Y., Wang, H., & Huang, W. (2022). Exploring the effects of interactive video-based learning on students' critical thinking skills and learning satisfaction. *Journal of Educational Technology & Society, 25*(1), 153–165.

Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2021). *Intelligence unleashed: An argument for AI in education*. Pearson. https://www.pearson.com/ai-education

McDonald, C. (2017, October 27). Almost 70% of teachers think they do not have the skills to teach coding. *Computer Weekly*. https://www.computerweekly.com/news/450429016/Almost-70-of-teachers-think-they-do-not-have-the-skills-to-teach-coding

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2020). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education, 70*, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Morehouse, B. L. (2021). Adaptations to a face-to-face initial teacher education course 'forced' online due to the COVID-19 pandemic. *Journal of Education for Teaching, 47*(2), 248–251. https://doi.org/10.1080/02607476.2020.1839656

Mouzakis, K. (1995). *Teachers and Computers: Attitudes of Greek Teachers towards the Introduction of Computers in General Education*. Kyriakidis Bros.

Naresh, R. (2020). Education after COVID 19 crisis based on ICT tools. *Purakala, 31,* 464–468

OECD. (2021). Who are the teachers? In *Education at a glance 2021: OECD indicators.* OECD. https://www.oecd-ilibrary.org/education/education-at-a-glance-2021_69096873-en

Okagbue, E. F., Ezeachikulo, U. P., Nchekwubemchukwu, I. S., Chidiebere, I. E., Kosiso, O., Ouattara, C. A. T., & Nwigwe, E. O. (2023). The effects of COVID-19 pandemic on the education system in Nigeria: The role of competency-based education. *International Journal of Educational Research Open, 4*, 100219. https://doi.org/10.1016/j.ijedro.2022.100219

Pasinou, E. (2021). *Technological innovation and its impact on the educational process.* Papazisis Publications

Pelpadakis, S., &Kalogiannakis, M. (2020). Using virtual reality in primary education: The technological affordances of an educational VR application. In T. Bastiaens& G. Marks (Eds.), *Proceedings of EdMedia + Innovate Learning* (pp. 1107–1113). Association for the Advancement of Computing in Education (AACE).

Perk, Y. (2021). A pedagogical framework for mobile learning: Categorizing educational applications of mobile technologies into four types. *International Review of Research in Open and Distributed Learning, 22*(2), 24–44. https://doi.org/10.19173/irrodl.v22i2.4944

Roch, P. J., Mason, S. L., & O'Leary, J. (2021). Measuring the effect of continuous professional development on elementary teachers' self-efficacy to teach coding and computational thinking. *Computers & Education, 168,* 104196. https://doi.org/10.1016/j.compedu.2021.104196

Salas-Rueda, R. A., Castañeda-Martínez, R., Eslava-Cervantes, A. L., & Alvarado-Zamorano, C. (2022). Teachers' perception about MOOCs and ICT during the COVID-19 pandemic. *Contemporary Educational Technology*, *14*(1), 1–17. https://doi.org/10.30935/cedtech/11479

Selwyn, N. (2023). Addressing the challenges of AI in education. *Educational Research Review, 35,* 100–110. https://doi.org/10.1016/j.edurev.2023.100110

Spiteri, M., & Chang Rundgren, S. N. (2020). Literature review on the factors affecting primary teachers' use of digital technology. *Technology, Knowledge and Learning, 25*(1), 115–128. https://doi.org/10.1007/s10758-018-9376-x

Tan, J. P. L., Choo, S. S., Kang, T., & Liem, G. A. D. (2017). Educating for twenty-first century competencies and future-ready learners: Research perspectives from Singapore. *Asia Pacific Journal of Education*, *37*(4), 425–436. https://doi.org/10.1080/02188791.2017.1405475

Tsimogyannis, A. (2019). *Digital technologies and 21st century learning.*Kritiki Publications

Tuncczyk, Ł., Jáuregui, V. C., de La Higuera Amato, C. A., Muñoz, D., Arteaga, M., Oyelere, S. S., & Porta, M. (2021). Are teachers techno-optimists or techno-pessimists? A pilot comparative among teachers in Bolivia, Brazil, the Dominican Republic, Ecuador, Finland, Poland, Turkey, and Uruguay. *Education and Information Technologies, 26*(3), 2715–2741. https://doi.org/10.1007/s10639-020-10380-4

Valverde-Berrocoso, J., Fernández-Sánchez, M. R., Domínguez, F. I. R., & Sosa-Díaz, M. J. (2021). The educational integration of digital technologies preCovid-19: Lessons for teacher education. *PLoS ONE, 16*(8), 1–22. https://doi.org/10.1371/journal.pone.0256283

Vander Ark, T., Liebtag, E., & McClennen, N. (2020). The power of place: Authentic learning through place-based education. ASCD

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the 21st century. *Journal of Computer Assisted Learning, 29*(5), 403–413. https://doi.org/10.1111/j.1365-2729.2012.00460.x

Waterson, J., & Milmo, D. (2021, October 25). Facebook whistleblower Frances Haugen calls for urgent external regulation. *The Guardian.* https://www.theguardian.com/technology/2021/oct/25/facebook-whistleblower-frances-haugen-calls-for-urgent-external-regulation

Xu, J., & Zhu, Y. (2023). Factors influencing the use of ICT to support students' self-regulated learning in digital environment: The role of teachers in lower secondary education in

503 Shanghai, China. *Psychology in the Schools*, *60*(11), 4312–4331.
504 https://doi.org/10.1002/pits.2293