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Integrating Information and Communication Technology with the Field of Education: Challenges and Issues

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Abstract

The deep integration of information and communication technology (ICT) and education has become an important trend in global education reform. This article reviews the research results, key challenges, and future development directions of ICT applications in education over the past 15 years. The study found that ICT has significantly improved the accessibility of educational resources, teaching interactivity, and personalized learning efficiency through tools such as online learning platforms, artificial intelligence-assisted teaching, virtual reality (VR) and augmented reality (AR) technologies, and big data learning analysis. Especially during the COVID-19 pandemic, ICT has become a core means to support distance education and ensure the continuity of education. However, existing research also reveals significant differences in technology application: the digital divide between developed and resource-poor regions continues to widen, teachers' technical literacy is insufficient, the design framework for technology-integrated teaching is missing, and over-reliance on technology may cause educational equity and ethical issues (such as data privacy and weakened students' social skills). Future research needs to explore sustainable ICT education integration models further, focusing on inclusive education policy formulation under technology empowerment, innovation in teacher professional development paths, and long-term social impact evaluation of technology education applications from an interdisciplinary perspective. This article provides theoretical references and practical inspiration for educational technology researchers, policymakers and practitioners.

Keywords: Information and Communication Technology, Education, TPB, TAM, UTAUT

Introduction

Human civilization has gone through three industrial revolutions (mechanization, electrification, and automation represented by information technology). It is currently entering an intelligent revolution represented by a new generation of information technology, such as artificial intelligence, big data, the Internet of Things, and blockchain. Each industrial revolution has profoundly changed the future production and lifestyle of human society, which has also had a significant impact on the education sector and talent training. The strength of education and technology determines the changes in the world civilization pattern

and the migration of scientific centers (Global Smart Education Conference, 2022). Technological innovation is triggering the third educational revolution. Future education in the digital age will be transformed from a single school and limited teachers to a cross-national, cross-school, and cross-border one. The means, methods, and processes of education will move from face-to-face education to a new model of virtual-real hybrid and human-machine enhancement. In addition, artificial intelligence will replace a large number of jobs. How education can adapt to the fourth industrial revolution requires active thinking and a positive response. To train the younger generation and prepare them for the fourth industrial revolution, educators and educational institutions need to take a proactive approach to update courses to focus on emerging technologies and industry trends (Global Smart Education Conference, 2024).

Information technology provides a platform for educational informatization, which obviously has advantages that traditional teaching cannot match. The traditional methods of teaching are typically characterized by a teacher-centered approach to direct instruction, where students are expected to emulate or comply with the teacher's demonstrations or directives (Theodorakou & Zervas, 2003; Oderinu et al., 2020). In traditional classroom teaching, new knowledge, information, and tasks often come from teachers and books, while in information-based classrooms, new knowledge and information often come from the internet, and learning expands from time and space to a wider range. It can be said that technology has driven the reform of classroom teaching. Integrating information and communication technology (ICT) into education is seen as a possibility of using modern technology to change outdated education systems (Buabeng Andoh, 2012).

Therefore, most countries in the world are emphasizing the integration of ICT into learning and teaching methods. Governments around the world, especially in developing countries, have been striving to improve their national plans for incorporating information and communication technology into education (International Telecommunication Union, 2010). Jhurree (2005) believes that the introduction and integration of ICT are based on ongoing educational reforms around the world. Many countries are highly concerned about the development of ICT skills in their education systems, and these countries have changed the goals of their education systems based on new innovations (Ezziane, 2007). According to Cox's (2013) research, the use of ICT in education is no longer just a government choice, but is seen as a significant investment.

The Positive Role of ICT in the Field of Education

In January 2024, the World Digital Education Conference was held in Shanghai, China. The theme of this conference is "Digital Education: Application, Sharing, and Innovation," which makes education digitalization once again the focus of the world's attention(MOE, 2024). According to Koc & Bakir's (2010) research, the education sector remains one of the most important beneficiaries of ICT. The study by Ahitarogah & Barfi (2016) found that incorporating ICT into teaching can significantly improve students' academic performance. In addition, the introduction of ICT can concretize abstract knowledge, stimulate students' interest, and enhance teacher-student interaction (Papayonon & Chalalambus, 2011). Given the advantages of integrated ICT, many countries are increasingly using this technology in their education systems (Bell, 2011). The popularity of ICT in the academic field exceeds imagination (Ahiatrogah & Barfi, 2016). Buabeng Angdoh & Yidana (2015) demonstrated that

ICT has brought new changes to teaching and improved the efficiency of knowledge transfer. Amedeker's (2020) study suggests that the use of ICT in teaching and learning can cultivate students who are committed to and capable of actively participating in self-directed learning and innovation. When students have the opportunity to construct knowledge through interaction with the environment, they are able to achieve better learning outcomes. By using relevant digital technologies to provide learners with a rich environment, their interaction with themselves, emotions, and cognitive environments can be better enhanced (Keengewe et al., 2009).

Besides students, lecturers are also one of the beneficiaries of ICT. Although according to occupational analysis surveys, the likelihood of teaching being replaced by artificial intelligence in over 360 professions in human society is only 0.4% (Frey & Osborne, 2013). However, this conclusion does not mean that the teaching profession can exist independently of modern information technology. Rosenberg & Foshay (2002) emphasized that current illiteracy does not refer to those who cannot read and write, but rather to those who cannot continue learning. With the rapid development of information technology and the availability of advanced online learning resources in the future, the ability to effectively access, evaluate, and utilize the necessary educational information has become one of the fundamental qualities for future lecturers (Falloon, 2020). At the same time, lecturers need to actively adapt to the changes of educational informatization such as artificial intelligence and information technology, and flexibly use information technology to carry out education and teaching, such as using information technology to create a vivid and colorful interpersonal interactive learning environment, effectively use the rich teaching resources provided by the Internet, and fully use information technology to assist teaching. These are the basic requirements for the future development of teaching occupation (Xue et al., 2022). This requires lecturers to understand new technologies, continuously learn new technologies, and actively apply new technologies to improve teaching.

Many countries and organizations invest in equipping schools with the latest digital technology tools, training lecturers to enhance their digital skills, and promoting their professional development (Enrique Hinostroza, 2018). On the one hand, with the rapid changes in the field of education and the increasing demand for high-quality higher education, people's expectations for the skills and professional level of lecturers have also been raised. On the other hand, with the rapid development of artificial intelligence technology, lecturers' expectations for their professional level are also increasing. Lecturers need to constantly learn to maintain their competitiveness and progress (Collinson et al., 2009). However, the rapid development of society and explosive growth of knowledge pose significant challenges to the traditional path of teacher growth. Top down training cannot meet the professional development needs of future lecturers (Demirel & Akkoyunlu, 2017). Only by maintaining the concept of lifelong learning, updating knowledge and concepts in a timely and proactive manner, can lecturers keep up with the pace of development. ICT provides a facilitating condition for knowledge sharing. ICT can not only provide real-life and interdisciplinary comprehensive learning environments for teaching, but also offer various learning technology tools for lecturers. In addition, online learning spaces also provide a platform for lecturers to access various services, offering them learning opportunities in online learning spaces (Maatuk et al., 2022). This poses a challenge for lecturers to have background knowledge in

education, computer science, and statistics, as well as to be adept at utilizing ICT to access resources.

The Epidemic became an Accelerator

Given the enormous impact of ICT, its contribution to the field of education cannot be underestimated. Especially affected by the COVID-19 pandemic, global education is facing significant challenges, and the resulting large-scale online learning has further accelerated the process of digital transformation in education (Sepulveda-Escobar & Morrison, 2020). In 2020, as the infection rate increased, many countries and regions ordered schools to close as a related containment measure (Viner et al., 2020). According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2020), the COVID-19 pandemic has affected the education sector in over 100 countries and regions worldwide, with over 1 billion students unable to attend school. ICT has provided support for the smooth implementation of teaching activities during the pandemic. However, there are significant differences in the readiness of schools in OECD countries for online education (Ikeda, 2020). According to the report, nearly half of the schools are unable to provide online learning platforms. In addition, one-third of lecturers lack the skills to use ICT to support teaching (Ikeda, 2020).

In fact, in the past, the focus of digital education development was usually on evaluating the completeness of schools' introduction of digital and information equipment, as well as distinguishing between external (infrastructure, policies) and internal (leadership, lecturers) barriers at different levels. However, due to the sudden outbreak of the pandemic, teachers no longer have the freedom to choose whether to incorporate digital tools into their teaching, as this is inevitable. Therefore, this pandemic has brought a brief boom in the use of digital technology. The pandemic has forced lecturers to accept and use digital teaching tools. The impact of Covid-19 on technology is ubiquitous, and some lecturers have stated that they would not consider the use of digital technology necessary if it were not for the pandemic. Some lecturers are also very surprised by the usability of digital tools (Wohlfart et al., 2021). However, the role of ICT in modern education is evident, but the frequency of incorporating ICT into higher education, especially in teaching activities in developing countries, is still unsatisfactory (UNESCO,2017).

Obstacles to Integrating Information and Communication Technology into Education

The current research results show that these factors are mainly divided into internal factors and external factors. External factors include the construction of infrastructure related to ICT, the implementation of training related to the use of ICT, and the support of organizations for the use of ICT (Shin, 2015), while internal factors mainly involve teachers' self-efficacy and ICT literacy (Coban & Atasoy, 2019).

Among many factors, a major debate is whether having a sound and complete infrastructure will increase the frequency of ICT application in higher education teaching (Rapanta et al., 2020). The survey found that existing research results tend to believe that the situation in low- and middle-income countries is more consistent with this argument (Turugare & Rudhumbu, 2020). In other words, in low- and middle-income countries, the lack of ICT-related infrastructure leads to low usage of ICT in teaching. These studies repeatedly report limited technology-related infrastructure and significant socioeconomic problems, which directly result in the lack of an important material basis for using ICT to transform teaching

practices (Rousinos & Jimoyiannis, 2019). For example, research results show that many African universities have not fully integrated ICT into the classroom, causing lecturers to continue to use outdated teaching methods in the classroom. The main reason for this phenomenon is that some African countries are economically backward and lack ICT infrastructure (Alaceva & Rusu, 2015). Some African countries do not even have access to the Internet (Alaceva & Rusu, 2015). Lack of ICT-related knowledge and skills is another objective factor that hinders teachers from using ICT (Lin et al., 2014). According to Rudhumbu (2020), most African lecturers lack the knowledge and skills to use ICT. In addition, strong policy support will greatly promote the integration of ICT and education, but many African countries also lack corresponding policy support (Singhavi & Basargekar, 2019).

Furthermore, although the European Commission has been committed to promoting the application of ICT in teaching, the situation is not optimistic (European Union, 2020). In fact, European countries also face challenges such as policy lag, funding shortages, and lecturers' unwillingness to change traditional teaching methods (Hennessy et al., 2005). Researchers have found that many instructors have not yet integrated technology into the teaching process (Lawless & Pellegrino, 2007).

In addition, there are other obstacles. With the rapid development of technology, the consistency between the beliefs and practices of lecturers has become particularly important in academic research. New technologies have brought new demands to the role of lecturers, thereby generating new perspectives for professional development. Therefore, lecturers need to combine advanced ICT technology with 21st century learning and teaching abilities (Robin, 2008). However, statistical data cannot provide information about whether lecturers are willing to use ICT in their teaching (i.e. whether they accept technology). As pointed out by Teo (2014), high usage rates may be the result of mandatory organizational requirements. In fact, although universities may make technology a mandatory requirement, lecturers still have their own attitudes towards whether to use technology in the teaching field (Yang & Huang, 2008). In addition, lecturers are unlikely to blindly use ICT under external pressure without considering teaching tasks (Fu, 2013). In fact, although universities may require lecturers to use ICT, in practice, lecturers still make trade-offs rather than blindly following mandatory rules (Yang & Huang, 2008).

According to Chiu et al. (2006), motivation is a precursor to behavior and a product of an individual's expectation that certain inputs will have a positive impact. However, many lecturers who are able to use technology lack motivation to do so because they are satisfied with traditional teaching strategies or feel anxious when faced with new digital choices (Mishra et al., 2020). Dhawan (2020) pointed out that the attitude of lecturers towards the use of ICT will be influenced by technology anxiety caused by distrust of ICT. According to Gulbahar & Guven (2008), although some lecturers recognize the benefits of technology, they lack motivation to integrate it into the classroom because they lack confidence in doing so. Similarly, integrating technology into the teaching process has also been hindered, as completing daily teaching tasks leaves them exhausted and lecturers with little time to enrich classroom teaching with technology (Hew & Brush, 2007). Teo's (2014) study found that lecturers with heavy workloads have a lower willingness to use ICT because their daily work has already exhausted them. Stols & Kriek (2011) pointed out that lecturers who do not recognize the usefulness of ICT are also unlikely to use it. In addition, lecturers lacking self-

efficacy reported lower frequencies of use (Stols et al., 2015). Some lecturers also limit their use of ICT to presenting teaching content through slides (Yang, 2015). In addition, Agbatogun (2013) pointed out that most university lecturers use technology for research purposes rather than integrating it into the classroom.

The ICT in education is expected to have a significant impact on learners' academic performance and experience. However, the effective implementation of information and communication technology ICT largely relies on the acceptance and use of this technology by lecturers (Kumar et al., 2008). Some studies have investigated the factors that influence lecturers to integrate different technologies into the classroom, including environment, policies, support, and beliefs. However, only a few studies have explored the factors that influence the use of ICT by lecturers in teaching (Lawrence & Tar, 2018). In addition, previous studies have tended to focus on students' use of technology, but empirical quantitative research on the use of ICT by lecturers in teaching has been largely overlooked (Mac Callum & Jeffrey, 2014).

Literature Review

The adoption of ICT is not only a technical issue, but also involves complex psychological decision-making processes, so there is no universal solution to these problems. The adoption of ICT is influenced by innovative features as well as various economic, social, organizational, and psychological variables (Chen et al., 2021). Alsaleh et al (2019) found in a cross-cultural study that a single model may not be able to predict the cross-cultural patterns of technology use. Almanthari et al (2020) report that there are significant differences among lecturers from different countries in terms of the most important barriers to using ICT. Naqvi (2018) argues in the article that simply mastering knowledge of ICT is not sufficient to effectively implement the technology, as various factors can affect the implementation of ICT in education.

However, it is currently unclear how these factors interact and hinder lecturers from using ICT for teaching (Earle, 2002). Therefore, research should examine these factors as a whole rather than focusing on certain aspects. Given the significant impact of ICT, incorporating it into higher education teaching is a global trend. However, the frequency of university teaching is relatively low globally at present (UNESCO, 2017). This study suggests that understanding the factors that determine the use of ICT by university lecturers in teaching will help predict the use of technology and improve the effectiveness of integrating ICT with teaching.

Table 1.1
Research on the Adoption of ICT in the Field of Education

NO.	Author	Journal	Behavioral Examine	Context	Theory	Method	Findings
1	Zenda & Dlamini (2023)	Education and Information Technologies	lecturers adopt ICT	**South Africa** (secondary school lecturers）	modified UTAUT model	Quantitative, self-report Questionnaire, N=100	ICT infrastructure, training policy, collaboration, ICT assessments and ability to communicate using ICT influence lecturers' adoption of ICT
2	Lomos et al. (2023)	Interactive Learning Environments	Variation in lecturers' use of ICT	**Luxembourg** (Public primary school lecturers)	The SAMR model	learning analytics approach, N=811	(1) lecturers who spent their active time online performing activities specific for Redefinition, followed by Modification, spent significantly more time online than those performing activities specific for Substitution and Augmentation (2) the more lecturers had previously used the platform, the more they used it (3) lecturers who attended incentive events spent significantly more time active online

3	Warioba et al. (2022)	Education and Information Technologies	Adoption of ICT as a pedagogical tool	**Tanzania** (community secondary school)	TPACK	Qualitative N=180 students + 30 lecturers	(1) possibilities for ICT adoption: presence of electricity; presence of ICT devices; presence of technical support and positive attitude toward ICT use (2) constraints for ICT adoption including insufficient of ICT devices: lack of technical support and lack of ICT skills and knowledge
4	Gökçearslan et al. (2022)	Interactive Learning Environments	Acceptance of educational use of the Internet of Things (IoT)	**Turkey** (Public university pre-service lecturers)	TAM	Quantitative, self-report Questionnaire, N=471	(1) perceived ease of use and usefulness contributed significantly to the attitudes toward using IoT (2) facilitating condition and the intention to use are positively related to each other (3) relationship between ease of use and intention to use was not direct but indirect (4) ICT competency and individual innovativeness have an indirect effect on the intention to use (5) The direct impact of ICT competency and

							innovativeness on ease of use is significant
5	Li (2022)	Journal of Educational Computing Research	lecturers' ICT acceptance	**China** (High school EFL lecturers)	TAM & TPACK	convergent QUANþqual mixed methods design, online survey N=186	EFL lecturers' TPACK perceptions（ICT usefulness and easiness of using ICT) and acceptance of ICT are closely correlated
6	Sun & Mei (2022)	Computer Assisted Language Learning	lecturers' adoption of educational technology	**China** (national key universities pre-service L2 Chinese lecturers)	(Technology Acceptance Perspective) Self-Created Model	Quantitative, self-report Questionnaire, N=331	(1) perceived usefulness, technology self-efficacy, and facilitating conditions were found to have direct positive effects on attitude (2) perceived usefulness, attitude, and experience of technology use had positive influences on intention
7	Sawyerr & Agyei (2022)	Education and Information Technologies	lecturers' use of ICT in classroom instruction	**Ghana** (Public high school mathematics lecturers)	the will, skill, tool, pedagogy (WSTP) model	Quantitative, self-report Questionnaire, N=92	will, skill, tool, and pedagogy four measures play together in implementing ICT in instruction
8	Pischetola (2022)	International Journal of Technology and Design Education	lecturers' technology adoption	**Brazilian** (public primary school lecturers）	Sterling's model（Levels of knowing）	Semi-structured interviews，N=80	(1) lecturers' beliefs are observed to be reliable predictors of ICT uses and adoption

							(2) lecturers' epistemic beliefs have shown a correlation with self-efficacy
9	Yusop et al. (2021)	SAGE Open	Use of ICT during teaching	**Indonesian** (preservice lecturers)	TPB	Quantitative, self-report Questionnaire, N=1133	(1) Normative beliefs are the strongest constructs for predictive technology use, followed by control beliefs and behavioral beliefs (2) There is no significant gender difference in the use of technology, but there are significant differences between different universities
10	Gurer (2021)	Education and Information Technologies	lecturers' acceptance of technology	**Turkey** (Preservice secondary school mathematics lecturers)	TAM	Quantitative, self-report Questionnaire N=530	(1) Facilitating conditions, subjective norms and attitudes directly affect willingness (2) Attitudes are influenced by both perceived usefulness and ease of use
11	Wohlfart et al.(2021)	Education and Information Technologies	Acceptance and usage of digital tools	**Germany** (secondary school lecturers)	TAM	Qualitative, semi-structured interview, N=15	The pandemic is a unique factor affecting the acceptance and use of technology in education
12	Arkorful et al.(2021)	Education and Information Technologies	Integration of information and communication technology in teaching	**Ghana** (Senior high school lecturers)	Diffusion of innovation theory	Quantitative, self-report Questionnaire, N=83	(1) Attitude and behavior have a significant positive correlation (2) There is no significant gender

							difference in lecturers' acceptance of ICT-supported teaching
13	Ergado et al. (2021)	Education and Information Technologies	barriers to ICT implementation	**Ethiopian** (University lecturers)	Information system theory (technology-organization-environment framework)	case study	Barriers identified were organizational factors such as inadequate ICT infrastructure, lack of confidence, lack of support from top management, limited funding for ICT build-out, lack of collaboration, and lack of skilled human resources
14	Bin et al. (2020)	British Journal of Educational Technology	adoption and gratification in new technologies	**China** (Public technical and vocational college lecturers)	Technology adoption and gratification (TAG) model	Quantitative, self-report Questionnaire, N=535	(1) perception of ease of use and advantage of ICT were directly affected by computer ability (2) intention to use ICT was directly affected by perceived ease of use and usefulness (3) gratification in using ICT relies on ease of use along with perceived usefulness and intention to use (4) actual use of ICT was directly affected by intention to use and

							perceived usefulness (5) use of ICT has three primary determinants: teaching purpose, research purpose and academic purpose
15	Kao et al. (2020)	*The Asia-Pacific Education Researcher*	Technology-Teaching Integration	**Taiwan** (primary school lecturers）	Not specified	Quantitative, self-report Questionnaire, N=368	lecturers' learning self-efficacy and learning attitudes influenced their technology integration
16	Shah et al. (2020)	Technology, Pedagogy and Education	lecturers' pedagogical relationship with ICT	**Pakistani** (lecturers in higher education)	Not specified	Qualitative, semi-structured interviews, N=29	Teaching beliefs instead of technology itself is more important to the use of technology
17	Shah et al. (2020)	Technology, Pedagogy and Education	lecturers' pedagogical relationship with ICT	**Pakistani** (university lecturers）	Phenomenographic study	Semi-structured interviews，N=29	no matter how well established the institutional technological infrastructure, without CCKB conception of ICT use, not all lecturers will adopt ICT with the aim of higher-level teaching and learning
18	Chen et al. (2019）	Educational Technology Research and Development	Use ICT to develop high-quality teaching activities	**China** (Primary and secondary school lecturers)	self-constructed model	Quantitative, Environment-based design (EBD) methodology, N=3730	Willingness to use, frequency of use, ITC, degree of help and application context are the five main factors affecting the use of ICT to carry out high-quality teaching activities

19	Islam et al. (2019)	Ieee Access	Use ICT in higher education	**Malaysia** (university lecturers）	technology adoption and gratification (TAG) model	Quantitative, self-report Questionnaire, N=397	(1) West Malaysian lecturers' perceived usefulness and ease of use mediated the relationships between computer self-efficacy, gratification and intention to use ICT (2) east Malaysian lecturers, only perceived ease of use did not mediate the relationship between computer self-efficacy and gratification (3) west and east Malaysian lecturers' intentions to use ICT mediated the relationships between actual use, perceived usefulness and ease of use
20	Kearney et al. (2018)	Teacher Development	lecturers' technology adoption	**Australia** (primary and secondary schools)	Not specified	mixed methods, interview, N=35 Questionnaire, N=200	lacking professional support and resource access are barriers in the early days of adoption and use of this technology
21	Gellerstedt et al. (2018)	Heliyon	Adoption of ICT pedagogy in schools	**Sweden** (elementary school lecturers)	Self-developed model based on UTAUT	Quantitative, self-report Questionnaire, N=103	(1) PE and actual use were also significant (2) Digital living was also correlated with Effort expectation (EE)

							(3) EE did not correlate with actual use
22	Salinas et al. (2017)	Education and Information Technologies	Adoption of information and communication technologies in teaching	**Chile, Colombia, Ecuado**（lecturers）	Not specified	Quantitative, online survey, N=89	Cultural differences between countries are important factors
23	Wu & Liu (2015)	Education and Information Technologies	Acceptance of ICT-mediated teaching/learning systems	**Taiwan** (Elementary school lecturers)	Innovation diffusion &TAM	Quantitative, self-report Questionnaire, N=340	(1) Cognitive style moderates the effect of ease of use on the adoption attitude of analytical style subjects (2) Trialability and fun of technology are important factors affecting attitude.
24	Vrasidas (2015)	British Journal of Educational Technology	lecturers' use of ICT	**Cyprus** (public primary school lecturers）	Not specified	mixed methods, interview, N=12 Questionnaire, N=531	The major barriers to ICT integration are the lack of time, the ill-structured design of the school curriculum, and the lack of access to ICT and support.
25	Mac Callum & Jeffrey (2014)	Computers in Human Behavior	Adoption of mobile learning	**European** decent, **Polynesian**, **Asian** or **African** descent	TAM	Quantitative, self-report Questionnaire, N=413	ICT literacy and anxiety are associated with higher perceptions that mobile technology is easy to use and useful
26	Mac Callum & Jeffrey. (2014)	Journal of Information Technology Education	lecturers' adoption of mobile learning	**European** decent, **Polynesian**, **Asian** or **African** descent	TAM	Quantitative, self-report Questionnaire, N=175	(1) Teaching self-efficacy is particularly important (2) Perceived ease of use has a mediating effect on perceived usefulness (3) Digital literacy has a

							direct impact on behavioral intentions (4) Digital literacy and the ability to use technology in the classroom are similar but different constructs (5) ICT anxiety negatively affects digital literacy and teaching self-efficacy
27	Agudo-Peregrina et al. (2014)	Computers in Human Behavior	Acceptance of electronic learning systems	**Spain** (Public universities graduate students & lifelong learning global offer)	TAM3	Quantitative, self-report Questionnaire, N=66 in Higher education N=81Lifelong learning	(1) direct influence of subjective norm and perceived usefulness in behavioral intention, and indirect influence of perceived ease of use in behavioral intention through perceived usefulness (2) the complexity introduced by TAM3 does not help to understand better the acceptance and use process (3) there is no significant relation between intention to use a system and actual behavior
28	Agbatogun (2013)	Educational Technology Research and Development	Interactive digital technologies' use	**Southwest Nigerian** (universities lecturers)	UTAUT & Expectancy-Value Theory	Quantitative, self-report Questionnaire, N=492	(1) Environmental factors can motivate and hinder the use of digital technology (2) The use of digital technology

							will be affected by the academic status of lecturers (3) Educational background, academic status, motivators, and barriers jointly affect the prediction of the use of digital technology
29	Blackwell et al. (2013)	Computers & Education	Adoption and use of technology	**USA** (Early childhood educators)	UTAUT	Quantitative, self-report Questionnaire, N=1329	Attitudes towards technology availability and teaching attitudes affect actual use of technology
30	Aldunate & Nussbaum (2013)	Computers in Human Behavior	lecturers' adoption of technology	**Chile**	Learning curve as a guideline	Quantitative, online survey N=80	lecturers' attitude towards new technology and the complexity of use technology are important factors
31	Hinostroza et al. (2011)	Computers & Education	Use of ICT in teaching	**Chile** (Primary and secondary state subsidized schools)	Not specified	National survey, Quantitative, self-report Questionnaire, N=68309	(1) On average, ICT use is infrequent; but in some specific activities it is frequently used (2) Middle school lecturers' self-awareness of their ICT skills is significantly higher than that of primary school lecturers (3) lecturers in high-performance and low-performance schools use ICT differently

32	Sang et al. (2011)	Journal of Computer Assisted Learning	ICT integration into classroom teaching	**China** (Primary school lecturers)	Self-constructed model	Quantitative, self-report Questionnaire, N=820	(1) Attitudes indirectly influence ICT integration through the mediation of ICT motivation and ICT supportive use (2) ICT motivation seems to be the strongest predictor of ICT use (3) the relationship between ICT school policies and attitudes is not supported (4) use of ICT is strongly influenced by internal teacher variables
33	Kidd (2010)	Education and Information Technologies	Adopt ICTs for teaching and learning practices	**USA** (lecturers in University of Georgia)	Not specified	Qualitative research, interviews, N=25	Organizational support, adequate and quality resources, teacher development and management and leadership are factors that affect lecturers' ability to use information and communication technology (ICT) in teaching
34	Al-Senaidi et al. (2009)	Computers & education	Barriers to adopting technology for teaching and learning	**Oman** (Faculty members in College of Applied Sciences)	Not specified	Quantitative, self-report Questionnaire, N=100	(1) Lack of support and lack of time are the main obstacles to the application of technology (2) Gender, academic ranking, academic field, and

							technology use frequency are not important determinants of perceived impairment
35	Hu & Webb (2009)	Education and Information Technologies	Integrating ICT to higher education	**China** (university business English teacher）	Activity theory	Semi-structured interviews，N=7	substantial change in ICT policy, which could promote lecturers' ICT related concepts, needs to be carried out to fulfil the potential of ICT for teaching and learning in China.

As the table above presents, by reviewing the latest research on the topic of adoption of ICT in the field of education from 2009 to 2023, surprisingly, developed countries do not dominate research in this field. Instead, the number of studies conducted in developing countries has increased significantly in recent years. This confirms what researchers have previously mentioned, that the digital transformation of education is a global trend. The significant increase in the number of studies conducted in developing countries also indicates that there is value in further exploring this field. In terms of research theories, TAM remains the most widely applied model, followed by UTAUT. Some studies have used their self-created models, while others have not specified the specific theory used. Studies using TPB as a theoretical framework are in the minority. For decades, a series of models for explaining the relationship between information technology and individual behavior have been developed. The Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) are currently the most applied models in the realm of technology acceptance and are recognized as representative models in this field (Han et al., 2017).

However, this study believes that TPB is necessary. First, because the use of ICT in teaching is itself a behavioral outcome, not a technology. Therefore, TPB is appropriate as a classic theory widely used to explain human behavior. Second, the introduction of modern technology in education is considered a key driving force for improving teaching. In order to encourage the use of technology in education, individual motivation to accept and apply technology is particularly important (Cheng, 2019). However, the value of motivation is overlooked in the TPB framework. Since the weakness of TPB has been realized, this study has added motivation factors. In addition, it is allowed to incorporate additional variables and combine other theories as long as these variables can make outstanding contributions to the explanation of behavior in the TPB model (Ajzen, 1991).

The theories currently used by the academic community to explain the behavior of technology use are mainly TPB and TAM. Many researchers have applied the TPB theory to various situations. For example, Lee et al. (2010) used it to explain the situation of lecturers adopting

educational technology, while Cheon et al. (2012) found that the theory can be used to explain the situation of college students using mobile learning devices. At the same time, Ahmed and Ward (2016) found that both TAM and TPB are suitable for explaining college students' acceptance of electronic devices. In addition, Wojciechowski and Cellary (2013) found that TAM can effectively explain students' intention to use image-based virtual reality learning environments. Teo et al. (2012) found that pre-service lecturers' attitudes toward ICT can be predicted by perceived usefulness and perceived ease of use, and subjective norms can also be used as a predictor of their intention to use technology. Besides, Cheng & Chu (2016) believed that students' intention to participate in online collaborative learning can be predicted by perceived behavioral control. However, as Cheng (2019) pointed out, researchers conducting studies using TPB and TAM have obtained conflicting results. Sa'nchez et al. (2013) found that the relationship between attitude and intention was not significant after controlling for perceived ease of use and perceived usefulness, while Warioba et al. (2022) believed that this study should be viewed with caution. result. Meanwhile, Yayla & Hu (2007) argue that using a single theory is more convincing than combining them.

In addition to the variables mentioned in the above two theories, researchers also suggest introducing other external variables to discuss their role in educational situations, like self-esteem (Ajzen & Manstead, 2007), which is considered an important predictor of attitudes, subjective norms, and perceived behavioral control (Cheng & Chu, 2016). Cheng (2019) found in the TAM model that self-esteem indirectly affects attitude through perceived ease of use and perceived usefulness. In the TPB model, self-esteem is a direct and significant predictor of attitude. This seems to indicate that the influencing mechanism of the relationship between self-esteem and attitude in TAM is precisely implicit in the TPB model (Cheon et al., 2012).

The results of Cheng (2019) also showed that combining TPB and TAM only slightly improved the explanatory power of the model compared with applying TPB alone. Furthermore, TPB provides more possibilities for explaining behavior and intention in the presence of external variables. Therefore, Cheng (2019) questions whether TAM may be a component of TPB. When considering the social impact and interpersonal interaction of technology use, TPB should be used as much as possible, while TAM may only be used to explore the acceptance of technology (Chu & Chen, 2016). If technology use involves interpersonal interaction, TPB should be given priority. If only the adoption of technology is studied, TPB's predictive ability is equivalent to that of TAM (Chu & Chen, 2016).

The efficacy of the Technology Acceptance Model (TAM) has been a subject of inquiry. Notably, TAM is limited to forecasting behavioral intentions rather than the actual behavior of technology usage. The underlying assumption of TAM is that intentions will inevitably result in behavior. However, research has demonstrated that the relationship between intention and behavior is not always certain (Bagozzi, 2007). Most studies on TAM employ quantitative research methods, with sample sizes ranging between 300 and 500, with no exclusion of larger or smaller studies. Furthermore, most research focuses on lecturers, with a surprising number of studies conducted on primary and secondary schools. Few studies are conducted on university lecturers. In addition, most studies concentrate on existing variables in TAM and UTAUT, with an inadequate assessment of other variables.

Conclusions

This study reviewed the research on the application of information and communication technology in education from 2009 to 2023, discussed the representative theoretical models and research methods, and summarized the research results. At present, the use of ICT to promote reforms in the education sector has become a global trend (Barnes, 2020). As mentioned in the previous discussion, there are two main factors that hinder teachers from effectively using ICT in the classroom (Ertmer, 1999). One type of barrier comes from external factors, such as the lack of facilities for the use of ICT in the organization and the lack of skills of teachers in this regard. Research shows that the main barriers to teachers' adoption of ICT are the shortage of required basic equipment, insufficient ICT infrastructure, and insufficient technical support for teachers (Joshi et al., 2021). The second type of barrier is related to teachers' beliefs about adopting new technologies and changing traditional teaching methods. Teachers' attitudes and beliefs affect their use of ICT (Prestridge, 2012). To be precise, teachers who have a positive attitude towards innovation in teaching methods are more likely to incorporate new technologies into the classroom (Arkorful et al., 2021). More importantly, research has found that internal barriers have a greater and more lasting impact on pre-service lecturers' use of ICT (Sánchez-Prieto et al., 2019).

According to UNESCO (2017), the role of ICTs in modern education is evident. However, integrating ICT into teaching has never been an easy task. Firstly, traditional teaching methods still dominate worldwide (Hinostroza et al., 2005). Secondly, the integration of ICT with teaching also involves explicit factors such as technical facilities, training, technical advice, as well as implicit factors such as attitudes and ICT skills (Larence & Tar, 2018). In addition, there are differences in the level of ICT development between different countries. Developed countries focus on improving their ICT integration strategies to help enhance students' abilities (Bradrup & Kowalski, 2002). In developing countries, including China, the integration of information technology and teaching is still in the early stages of improving information and communication infrastructure, enhancing the information literacy of lecturers, and promoting the application of ICT. Due to the complexity of influencing factors, research on integrating ICT into teaching cannot be promoted. Therefore, understanding the factors that promote the use of technology by lecturers in teaching will help encourage their use of ICT in their teaching. In addition, understanding the factors that affect the use of technology will provide guidance for education managers and policy makers in designing teacher education and training programs (Gurer, 2021). Future research can try to adopt a mixed research method to provide richer research findings. In addition to using a single theory, it is also possible to try to combine multiple theories to conduct research. In addition, regarding the population, future research can focus more on the field of higher education.

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