
BARRIERS AND FACILITATION FOR THE ACCEPTANCE OF INTERNET OF THINGS AMONG TEACHERS IN HIGHER EDUCATION SECTOR IN KARACHI

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ABSTRACT

Nobody can deny the change that technology has brought to the world of education. Technology has completely changed how we live our lives, from the innovative ways open universities teaching to the use of smartphones and tablets in the classroom. The Internet of Things also alters how individuals live and learn, in addition to how they go about their daily lives at work. (Tianbo, Z. 2012). Therefore, the teachers in the twenty-first century need to be efficient at integrating new technologies into curriculum and classroom practice as well as instructional strategies and technology use (Eisenberg & Johnson, 1996). Challenges and Opportunities are enormous with IOT in higher education. In addition to advancing the essential principles of teaching and research, the fascinating developments in ubiquitous computing, and with the advent of Artificial Intelligence, IOT technologies like cloud computing, machine learning are also beneficial in establishing a new, highly developed IOT centered education society. IOT deployment in educational institutions, however, can be compared to a new wave of change that has created new opportunities and prospects for improving both the physical infrastructure of educational institutions and the

teaching-learning process. The purpose of this study was to assess the potential of IOT in higher education, factors affecting its acceptance among higher education teachers and explore ways to maximize its benefits while resolving its drawbacks and reducing its hazard. This study aimed to increase knowledge, awareness and understanding surrounding their unique perspectives in order to gain an insight into how this immersive technology could be used to improve the integration and deployment of IOT in the Higher Education Sector.

KEYWORDS

Internet of things, IOT, 4th Industrial Revolution, 4IR, Higher education, e-learning, Technology acceptance model

INTRODUCTION

Technology in education is not a new subject. Although it has been extensively explored in a lot of studies for decades, a new paradigm of technology integration in the shape of the Internet of Things has given the digital and educational sectors a fresh start. (Amasha et al., 2020) as cited in (Gökçearsan et al., 2022). The traditional and conventional techniques of classroom instruction are no longer attractive to 21st-century learners due to the immense development and cumulative impact of AI and technology in many parts of life. Technology has now changed the educational world, and the learners of the 21st century are now recognized as digital natives who are living in the era of the digital world. Technology advancements have driven practical changes in education throughout history (Frick 1991). According to Dawes 2001, who was referenced by (Ghavifekr et al., 2016), In ways that were previously impracticable, new technologies have the power to maintain instruction across the curriculum and offer opportunities for successful student-teacher communication. Various studies conducted around the world show that using IT tools in Teaching and learning procedures has many benefits. (Nair & Das 2012). (Keengwe et al., 2009), contend that faculty researchers need to become familiar with, make use of, and incorporate technology into their teaching. Thus, the impact of technology on education has already been widely developed among researchers. But the importance of acceptance of that technology among the major stakeholders, like teachers, is why teacher educators play a key role in the implementation or deployment of any technology and with enormous growth and an aggregate part of technology in almost every field of our lives, traditional and orthodox methods of education in the classroom are no longer appealing and appealing to 21st-century learners. (Pervez & Alandjani, 2011).

The Internet of Things is among the main change agents along with AI in this new era, which has been ushered in by recent technological breakthroughs that have brought about enormous changes. This new paradigm of the integration of technology in the

form of IOT was introduced with the rise of the 4th Industrial Revolution (4IR), which has brought a new wave to the digital and educational sectors. In Germany, the fourth industrial revolution (4IR), in which technology is integrated into communities, was launched. According to (Baygin et al., 2016), The potential for devices, machines, sensors, and people to communicate with one another and with one another—especially over the Internet (the Internet of Things—IOT)—is Industry 4.0's most significant aspect.

One of the key elements of the fourth industrial revolution is IOT. (Al-Emran et al., 2020). The Internet of Things is slowly but steadily making its way into educational institutions in a variety of ways (Kiryakova et al., 2017). Thus, in the near future, the IOT technology will be used to differentiate e-learning and to create e-learning environments through the use of various technologies including augmented reality, virtual reality, wearable technology, big data, etc. Currently, Pakistan lags far behind in the deployment of IOT technology in its higher education sector due to a lack of awareness, access, and competency required to enforce the adoption o/f this technology among the major stakeholders of the education industry.

Lack of awareness, desire, and comprehension necessary to support the development of a learning environment that incorporates the use of IOT technologies to improve teaching and learning procedures and the instructional designs utilizing these technologies can be seen as a significant problem and deficiency in the industrial growth (Gökçearsan et al., 2022), and development of the education sector as well as in teachers' professional development. The study by (Moraes, et al., 2022) found that although Industry 4.0 technologies assist the entire learning process, they are not utilized to their full potential. In light of this, it is crucial to get instructors ready to incorporate new technologies, like the Internet of Things, and in order to do so, it is needed to look at the elements that influence their acceptance of the IOT. (Al-Abdullatif et al., 2022)

In order to increase the adoption of IOT and identify the elements that influence teachers' behavioral intentions to use IOT technology in their future teaching careers, this study looked into the data from the perspectives of the teachers teaching in the higher education sector. It looks at the important elements that affect people's intentions to use IOT in education. Compared to other industries, IOT utilisation in the education sector is still very new. To improve its quality, this industry is open to incorporating emerging technologies (Yildiz Durak H.2019). The Internet of Things has a huge capacity to eliminate all barriers to education, including geographic distance, linguistic difficulties, and economic development, claim (Banica et al., 2017). Although COVID-19's introduction has driven the swift adoption of technology-integrated classrooms and the idea of digital education around the world,

The revolutionary digital gap in Pakistan's educational system will be further filled by this study. The adoption of IOT technology in the classroom will transform the roles that teachers play as educators and need the development of their digital skills. (Hu et al., 2021) examined how technologies like the Internet of Things are used in education in order to improve teachers' technological pedagogical and content knowledge (TPACK) and let them keeping up with advancements. Unless instructors have the abilities, information, and attitudes required to integrate technology into the curriculum, it won't be employed. (Govender 2012) To help students grow their knowledge, abilities, competence, intentions, and attitudes towards new technologies, teachers must be knowledgeable about how to use digital technologies in relation to practical issues (Yildiz Durak H., 2021a; 2021b).

In addition to these benefits, this study will aid in the introduction and promotion of IOT integration in Pakistan's higher education sector, which will support the country's economy. Hence, educational institutions that stay current with technology advancements and change will have enormous development chances (Almetere et al., 2020). Additionally, it will bridge the gap between the third and fourth industrial revolutions' implementation and improve the desire of major stakeholders in the higher education sector to accept and adopt the use of IOT technology as a crucial tool. Additionally, it will create a thorough grasp of the applications and uses of IOT-connected devices in the educational sector.

LITERATURE REVIEW

The phrase "Internet of Things" or "IOT" was first used by Kevin Ashton in 1999. They illustrate a system using IOT in which omnipresent sensors link the real world to the internet Without even taking into account the hype and hopes for the future, the IOT 's actual reality—billions of physical objects connected via the Internet or other network technology—is already astounding. These objects have digital sensors. According to Juniper Research, “In 2015, an estimated 13.4 billion devices were connected, which is more than twice as many as there were people on the planet.” (Educause 2016), and this figure is predicted to triple to 38.5 billion devices by 2020”. “Around 75 billion IOT-enabled devices will be installed globally by 2025”. (Statista, 2021).

“IOT technology has a lot of potential to enhance the teaching and learning process and make "anytime, anywhere" a reality”. (Marquez et al., 2016), and very few articles, especially within the context of developing nations, have concentrated on using the IOT in education. (Putjorn et al., 2018). For example, in a recent systematic review (Al-Emran et al., 2020), it was analyzed that adoption and potential use of the Internet of Things IOT in education are still uncommon, particularly in developing nations (e.g., Pakistan, Sri Lanka, and Saudi Arabia). (Banica et al., 2017). This

provides enough opportunity for research into the problems affecting IOT implementations in education, particularly in underdeveloped nations. This field has little and only recently undergone research. In order to digitally revolutionize teachers' roles in the educational system, it is vital to identify their readiness, technological acceptance, and intention to use technologies (such IOT) in their future classrooms. Hence, by addressing this requirement, the current study seeks to add to the body of literature. (Majeed & Ali, 2018) assert that it is crucial to train instructors to incorporate emerging technology because the IOT cannot be ignored. By establishing a connection between people and other people, people and other things, or things and other things, it establishes a network and links people and other things (Talwana & Hua, 2016). The significant Internet of Things application is shown in Figure 2.

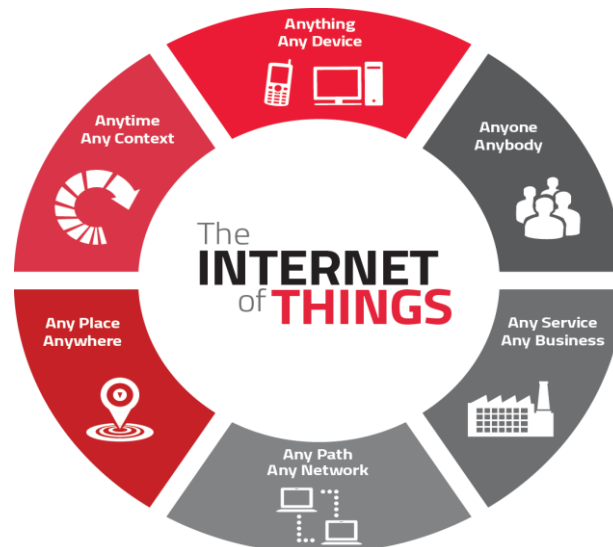


Fig 1: Significant Application of the Internet of Things

Concept of IOT (Smart Things)

The word "smart" has gained a lot of popularity nowadays. Smart homes, smart cities, and smart technology are buzzwords of the day, and people are becoming increasingly interested in how they may improve people's lives. The idea of the Internet of Things is most frequently linked to the word "smart" IOT. (Kiryakova et al., 2018). Smart education seeks to enhance students' capacity for lifelong learning. It emphasizes contextual, personalized learning to foster learners' development of intelligence and support their capacity for problem-solving in intelligent contexts. Research proved that these technologies have already shown their impacts all around the world". The terms "smart teaching" and "smart learning" are ones we may anticipate coming across in commentary on educational practice. They undoubtedly

do (Ambrose et al., 2010). Thus, the Internet of Things has the ability to break down all educational boundaries like geographic location, linguistic barriers, and economic development. Learning becomes quicker and easier because to the integration of technology and education, which also raises students' levels of knowledge and, inferentially, their overall quality. It does not, however, yet have widespread functioning models and standards, as with any newly developed notion. Universities are not yet ready to adopt all of the changes that the IOT has suggested for the educational sector in the real world.

IOT and Industry 4.0 (4th Industrial Revolution)

Industry 4.0 is a new, growing concept that intends to transform the physical world to a virtual world through intelligent digital change, reducing distances, removing barriers, and organizing real-time global transmission of information and material transactions. The industry 4.0, commonly known as “The fourth Industrial revolution”, has completely changed how an industry or business operates and develops. (Alkhalefah et al., 2020). With the advent of artificial intelligence and machine learning, the fourth industrial revolution has significantly advanced technology. We live in the "Industry 4.0" era, where the instructor serves as a tutor and the student is the active agent of their learning. (Fisk 2017). We are currently going through the fourth industrial revolution (4IR), during which society has assimilated technology. The Internet of Things (IOT), cloud computing, cognitive computing, and other manufacturing technologies all fall under the umbrella of the current automation and data sharing trend known as 4IR. The physical system is transformed into an internet-based IOT system that interacts with people in real-time over a wireless network. The education industry, in contrast to other sectors, takes a little longer to adapt to the changing demands of the education market brought on by revolutionary technology.

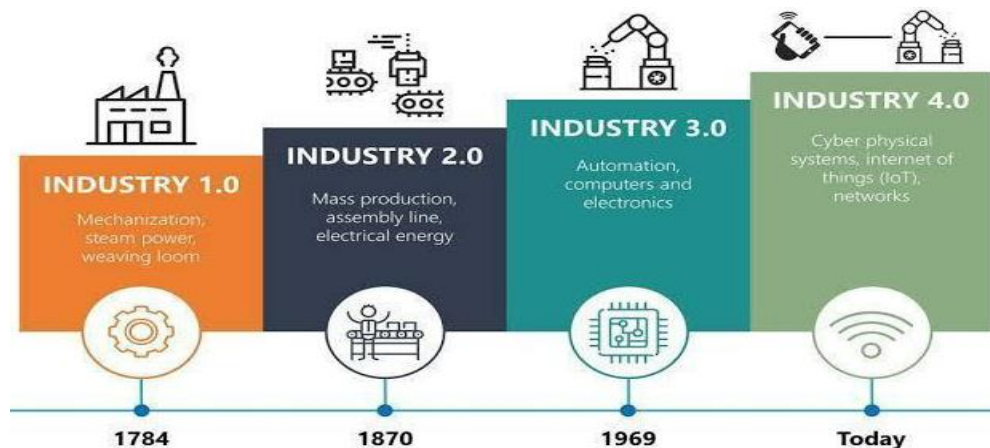


Fig 2: Stages of the Industrial Revolution

Teachers' Attitude towards technology

Studies (Lawless & Pellegrino 2007; Lee, Cheung & Chen 2005; Kersaint 2003), have shown that the attitudes of educators, who ultimately decide how and when technology will be used in the classroom, play a significant role in the successful implementation of educational technologies. Many characteristics that influence attitudes towards technology have been identified in other studies like (Nicolle & Lou 2008; Knezek & Christensen 2002; Li 2002; Rogers 1995) as these studies provide the complexity of the technology, the relative advantage of the technology, the ability to observe the technology in use. One of the biggest challenges for educators today is incorporating technology into their lessons (Cennamo et al., 2010; Wang, Ertmer & Newby, 2004, as cited in Giles & Kent, 2017).

(Mishra & Koehler, 2006), emphasized that teachers should get a solid comprehension of the technology in addition to being technology users. This entails knowledge of the ways in which a certain subject matter may be taught using technology, as well as the ways in which the subject matter can be changed to increase the educational value for students. This comprehension, which is founded on the fusion of technological, pedagogical, and subject knowledge, TPACK may result in creative methods to integrate technology into current teaching practices. (Al-Abdullatif, et al., 2022) hence place a high value on teachers' technical expertise, and technology integration in the teaching-learning process has grown to be a substantial part of the educational system. To help teachers, better respond to the difficulties and opportunities posed by the fast adoption of technology, universities and institutions should offer for teachers' extensive digital literacy training. Moreover, the characteristics of the technology itself, according to (Rogers 1995), are one of the key elements influencing people's attitudes towards a new technology. As predicted by Pervez et al., 2018 Education is heading into an entirely virtual system with complicated computing and artificial intelligence. Future changes will result from the introduction of robots, with minimal human interaction becoming the norm. A significant area of research currently centers on teachers' technological literacy and how technology is incorporated into the curriculum.

According to (Graham et al., 2009) understanding how to use educational technologies effectively has come to be widely acknowledged as a crucial component of a teacher's knowledge base for the twenty-first century. In this sense, technology encompasses more than just the usage of IOT tools; it also builds intricate connections between artefacts, artefacts, and practices (Koehler & Mishra, 2005). In order to enhance the effectiveness of the teaching process, higher education institutions are concentrating on technology-facilitated learning environments. Technology is currently regarded as being a crucial component of delivering high-quality education, according to (Ertmer 2005). More research has shown that the use of technology in education necessitates that teachers increase their technological literacy in order to better integrate a variety

of technology tools into their instruction (Goodyear et al., 2005). The rate at which technology has advanced is remarkable. Teachers in the present era work with "digital natives", people who grew up with new technologies as an everyday part of their lives in many different nations. Technology allows us to (co-)create, gather, store, and utilise knowledge and information. (Scherer et al., 2019).

The Internet of Things and Education

IOT offers a variety of opportunities for learning and the learning environment, from providing an effective learning environment (Zaerovet al., 2020) to designing individualized learning environments with learning analytics to increase security at the university. (Meacham et al., 2018). According to a study that combined the usage of mobile devices and IOT technologies, the environment where these technologies were employed together had a favorable impact on the teachers' ability to integrate technology (Hu et al., 2021).

(Bebell et al., 2016) talked about how teachers and students might use mobile devices to encourage innovation, creativity, shared learning, and inventive, experiential learning outside of the classroom. By utilizing new technologies, learning systems can be made better to reduce expenses and improve the full cycle of general learning (Mathews & Gondkar, 2017). In the IOT era, teachers and students are always connected to and have full access to discuss problems and develop solutions. Also, it will improve how educators engage and work together with more students outside of the walls of the university. Hence, Education can be more easily accessed and used if it can be done at any time and from any place (Pei, et al., 2013).

The Proposed Research Framework

The effects of individual user features, social environment, and technical qualities on the acceptance of IOT technologies in education have only been briefly discussed in previous studies. This study seeks to provide a survey methodology that analyzes the acceptance of IOT technology due to the lack of existing studies in the field. In this context, the use of new technologies is explained by adapting a causal relationship between beliefs, attitudes, intentions, perceptions, and behavior; developing and testing an integrative factor model that determines IOT technology acceptance. This conceptual framework was influenced by the TAM and the UTAUT, which were developed for use in education by (Ionescu-Feleaga, L., Ionescu, B. Ş., & Bunea, 2021). and offered by (Davis 1989) and (Vankatesh 2003). Thus, with a focus on teachers in the higher education sector, this study intends to analyze the anticipated usage of the IOT based on the technology acceptance model (TAM).

TAM “Technology Acceptance Model” (Davis 2003)

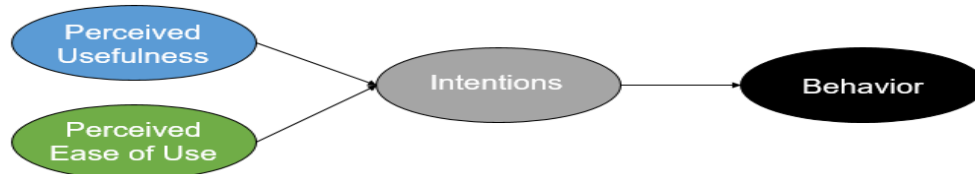


Fig 3: Technology Acceptance Model by Fred Davis 1989

In 1989, Davis put forth the TAM as an extension of the “Theory of Reasoned Action” (TRA) (Ajzen and Fishbein, 1980). It was created in order to comprehend how well users accepted IT. The TAM separates the perceived ease of use (PEU) and perceived “The technology acceptance model (TAM)”, a theory of information systems, simulates how individuals adopt and use technology. It is the most extensively studied theoretical model used to explain the acceptance of new systems and other information technologies, has been utilized by the researchers. The Theory of Reasoned Action (TRA). Ajzen and Fishbein’s 1980 “theory of reasoned action” (TRA) is a best-informed theory of IT adoption that asserts that overall IT acceptance or utilization is based on users' beliefs about things like (a) “a system's perceived usefulness (PU)” and (b) “a system's perceived ease-of-use (PEOU)”, which are significant determinants of their (c) “attitude towards use (ATT)” and (d) “behavioral intention to use (BI)”. Davis, first put forth the TAM model (1989). It is among the most often used frameworks for analysing people's attitudes about technology. “Users' attitudes towards using the technology and their intents are positively influenced by perceived usefulness and ease of use, which in turn affects how the technology is actually used”. (Teo, Fan, & Du, 2015).

“The Unified Theory of Acceptance and Use of Technology” (UTAUT)

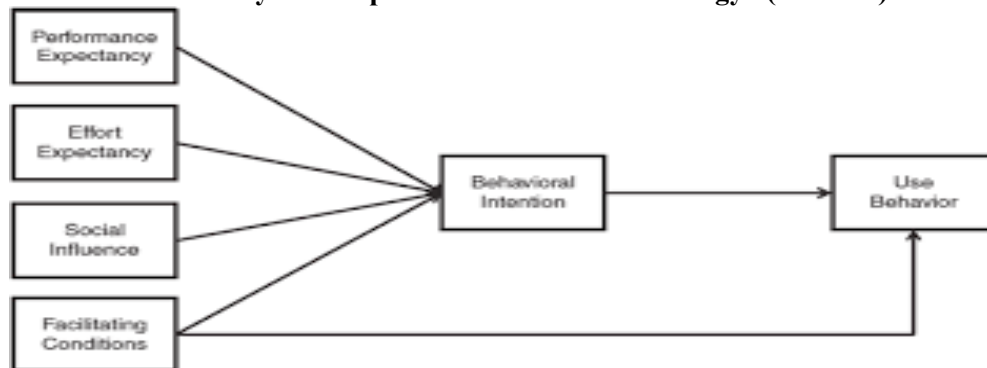


Fig 4: UTAUT (Unified Theory of Acceptance and Use of technology) Model by Venkatesh 2003

“The Unified Theory of Acceptance and Use of Technology” was developed by (Venkatesh, Morris, Davis, G. B., & Davis, F. D. 2003) in an effort to combine the key elements of competing user acceptance models (UTAUT). Both user intentions to utilize an information system and subsequent usage behavior are intended to be explained by the UTAUT.

According to the idea, there are four main constructs: 1) facilitating conditions 2) performance expectancy 3) effort expectancy, and 4) social influence. (Venkatesh et al., 2003). Subjective norms may affect one's intention to use a technology as well as its PU, according to the internalization impact described in both TAM and UTAUT; in addition, they affect one's attitude, subjective norms, the TRA model's constructions as well as PU and PEU in TAM. An attitude is regarded as having an impact on behavioral intention in both models. Davis stated that it was possible to overlook the impact of subjective norms on behavioral intention, hence TAM did not take these variables into account. (Davis FD., 1989)

IOTAM (Internet of things acceptance Model (Tsourela, M., & Nerantzaki, D. M. (2020))

Hence, this model is a reasonable attempt to add to the literature on IOT adoption. Future studies should expand the IOTAM and take into account more antecedents in order to test its final hypothesis. Overall, the new IOT acceptance model's (IOTAM) relevance offers the possibility of fostering an understanding of IOT dynamics. By providing a list of techno-psychological variables that define IOT acceptance and aiding in the development of strategies for those in management and other roles who are willing to take part in the successful implementation of IOT, the findings will be used to advance knowledge in this recently introduced technology.

Conceptual Framework

The current work aims to address this research finding by identifying the critical factors that affect IOT acceptance in order to increase awareness of collaborative and shared learning, where technology acts as the main tool for increasing the use of IOT. To better understand how the educators of higher education institutions are adapting to the Internet of things IOT, this study will focus on IOT uptake and acceptance. How it helps educators collaborate, communicate, and operate can be influenced by how it is used in learning environments. An in-depth examination of the factors influencing the adoption and use of the internet of things in Pakistan's higher education institutions is presented here.

“The Technology Acceptance Model”, TAM (Davis 2003) and “Unified theory of acceptance and Use of Technology”, UTAUT (Venkatesh et al., 2003) models are combined, and a framework is modified to determine the study's goal.

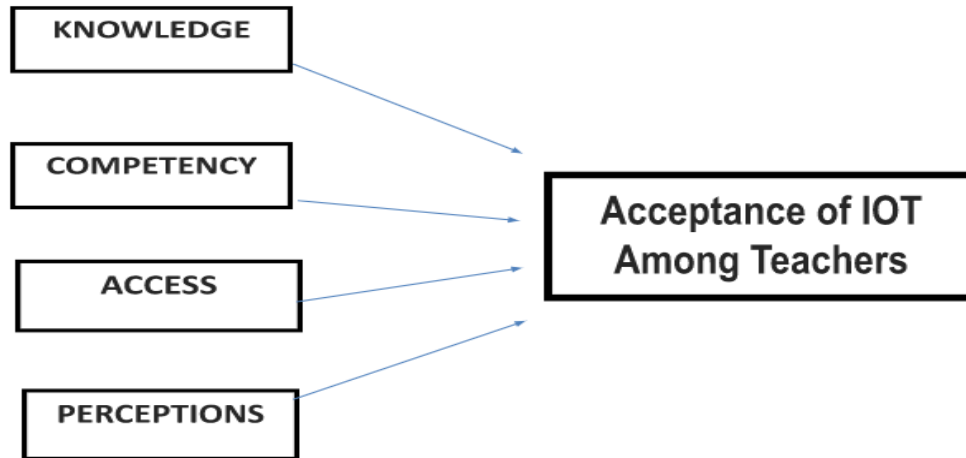


Fig 5: Model Adapted from TAM (Davis 2003) and UTAUT (Venkatesh et al., 2003)

RESEARCH OBJECTIVES

1. To Examine IoT's role in enhancing teachers' TPACK.
2. To Investigate teachers' digital skills for IoT integration.
3. To Explore teachers' attitudes toward digital technologies.
4. To Promote IoT adoption in Pakistan's higher education.
5. To Analyze IoT-driven development opportunities for institutions.
6. To Bridge the gap between the 3rd and 4th industrial revolutions.
7. To Encourage stakeholders to adopt IoT in education.
8. To Develop a clear understanding of IoT applications in education.

RESEARCH QUESTIONS

1. Is there any significant relationship between the Knowledge of teachers about IOT and their acceptance of this technology in their teaching practices?
2. Does the competency of teachers for using IOT is impacting the acceptance of IOT in any way?
3. Do teachers have access and proper facilitations from their institutions to use and adopt IOT based devices?
4. Do the perceptions of teachers for the usefulness of this technology have any significant relationship, for its adoption and integration in the higher education sector?

RESEARCH METHODOLOGY

A Descriptive Survey design was employed to meet the objectives and research questions of this study that focused on the perceptions, competencies, and access of teachers to IOT Technology. A closed-ended structured questionnaire was used to

determine the effect of different independent variables on a dependent variable. The survey questionnaire included demographic profile and construct items, with 65 statements on the topics of this study. Participants were selected using a random sampling technique, and each statement was scored on a five-point Likert scale. Appendix B includes the questionnaire.

After the data had been cleaned, 150 responses, including 65 (43.3%) male teachers and 85 (56.6%) female teachers, were selected for the study. There were 150 remaining valid responses once the outliers were taken away. This study was conducted in Karachi, collecting data from a mix of socioeconomic backgrounds of university teachers, lecturers, and professors from public and private sector universities. 326 Participants took part in the study. The study aimed to gain a diverse sample and range of experiences of using IOT devices. After analyzing the data, the internal consistency of the instrument was evaluated using SPSS V.22, and the instrument's total reliability was calculated at 0.860. Multiple regression analysis was used to examine how the independent variables affected the dependent variable, and the hypothesis was tested to assess the validity of data from the sample. According to Creswell. J.W. & Creswell, J.D. (2017), hypothesis testing is a method for assessing the validity of data from the sample.

DATA ANALYSIS

Demographic data

The sample included 85 (56.6%) female teachers and 65 (43.3%) male teachers from both private and public universities in Karachi City. 33 percent of them (50 respondents) were above 30 years, 66 respondents (44.1%) were in the 42–49 age range, and 34 respondents (22.6%) were in the 50–59 age range. In addition, of the 150 respondents, 31 (20.6%) held a master's degree, 28 (18.6%) had an MA, 47 (31.3%) had an M.Phil., and 44 (29.33%) had a PhD.

In addition, 33% of the teachers had more than ten years of experience in teaching, 21.6% had between five and six years, 54.3% had above 20 years, and 13.4% had more than twenty five years., Moreover, 22.6% of teachers were from the English department, 8.9% from the computer studies department, 7.5% from microbiology, 10.5% from applied physics, 28.9% from the business administration department, 10.5% from the humanities, 3.3% from rehabilitation sciences, and 3.3% from the media sciences department, and only 4.6% came from the education and social science department.

Table. 1 reveal that slightly more than half (57%) of the professors are middle-aged, or between the ages of 31 and 40. Consequently, there are still plenty of professionals in education and information technology who are willing to discover fresh approaches

to incorporating technology into their teaching methods. The fact that most university employees (69%) are men further demonstrates that diversity concerns in these colleges remain a challenge.

This indicates that more work needs to be done to raise instructors to the doctoral level, which is a requirement for most university lecturers. Since the bulk of the faculty (75%) have more than 10 years of teaching experience, they should be able to adapt effectively to incorporating technology into teaching and learning since they have been in the classroom for a while.

Quantitative descriptive analysis

Fig 6. Gender

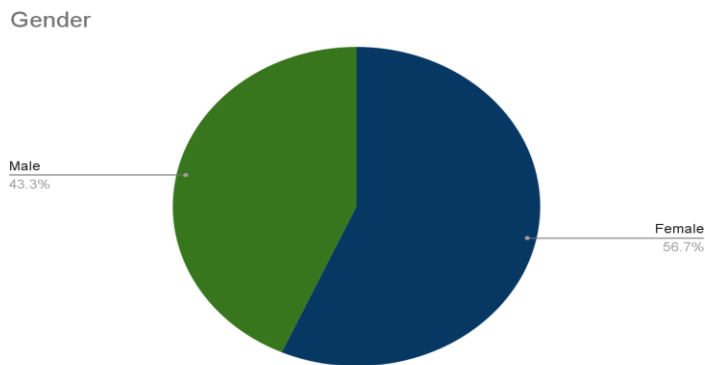


Table 1: Gender * Age Cross tabulation

Valid	Female	85	67.5	67.5	67.5
	Male	65	32.5	32.5	100.0
	Total	150	100.0	100.0	

Crosstabs 40 women above the age of thirty. Over the age of 40, there are 31 men and 35 women. 09 men and 25 women over the age of 50 are present. The majority of teachers are over 30 years old.

Table 2: Teaching Experience *Crosstabs Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
gender * TE	150	100.0%	0	.0%	150	100.0%

Table 3: Gender * TE Cross tabulation

Gender				
Female	21	65	14	95
Male	12	30	08	55
Total	33	95	22	150

The study's male and female teaching experience ratios are shown in the table. There are 21 females and 12 males with more than ten years of experience. There are 14 females and 8 males with over 25 years of expertise. There are 65 females and 30 males with over 20 years of experience. The majority of teachers have at least 20 years of experience.

Table 4: Reliability Analysis

Reliability Statistics	
Cronbach's Alpha	N of Items
.939	65

There are 65 questions in the questionnaire that was created to conduct this investigation. The value of Cronbach's Alpha in Table 4.8 is (=.919), which is adequate for item reliability and indicates that all questionnaire items are 92 per cent reliable. Currently, the total dependability is 94%.

Table 5: Scale of Acceptance of IOT (AIOT)

Reliability Statistics	
Cronbach's Alpha	N of Items
.839	10

Table 6: Scale of Knowledge of the Internet of things (KN)

Reliability Statistics	
Cronbach's Alpha	N of Items
.915	9

Table 7: Scale of Competencies in using IOT (CU)

Reliability Statistics	
Cronbach's Alpha	N of Items
.795	25

Table 8: Scale of Access of using IOT (AU)

Reliability Statistics	
Cronbach's Alpha	N of Items
.795	10

Table 9: Scale of Perception for the usefulness of this new technology (PU)

Reliability Statistics	
Cronbach's Alpha	N of Items
.895	22

Table 10: Regression Analysis

Model Summary				
Model	R	r ²	S. E	D-Watson
1	.989 ^a	.835	1.46649	1.769

a. Predictors: (Constant), AIOT (Acceptance of IOT)

b. Independent Variable: KN, CU, AU, PU

Table 11: ANOVA^a

Model	Sum of Squares	Df	Mean Square	F	Sig.
1 Regression	709.869	5	102.974	79.510	.000 ^b
Residual	623.723	302	1.767		
Total	1373.792	307			

a. Predictors: (Constant), Acceptance of IOT

b. Independent Variable: KN, CU, AU, PU

Table 12: Coefficients^a

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Err	Beta		
1 (Constant)	5.786	1.075		5.453	.000
KN	.364	.049	.260	5.115	.002
CU	.064	.040	.162	4.099	.000
AU	.344	.049	.240	5.115	.002
PU	.369	.045	.267	4.112	.000

a. Predictors: (Constant), Acceptance of IOT

b. Independent Variable: KN, CU, AU, PU

Table 13: Hypothesis testing - H1

H1	V	C Con	t	P	Decision
H1: IOT has a significant relation with KN	KN	.342	6.435	.001	Accepted

Table 14: H2

H2	V	C Con	t	P	Decision
H2: IOT has a significant relation with CU	CU	.392	6.485	.001	Accepted

Table 15: H3

H3	V	C Con	t	P	Decision
H3: IOT has a significant relation with AU	AU	.442	7.435	.001	Accepted

Table 16: H4

H4	V	C Con	t	P	Decision
H4: IOT has a significant relation with PU	PU	.442	7.435	.001	Accepted

DISCUSSION

The study focused on Teachers' Knowledge, competency, Access and their perception of usefulness in forecasting the acceptance level among the teachers. The results of the hypothesis testing revealed a substantial correlation between teachers' knowledge, competence, access, and perception of the value of IOT in the classroom and teachers' acceptance of IOT. According to the results, of the four predictors for teachers' level of acceptance and use of this technology, their level of skill with IOT is the most important. However, their steadfastly positive attitudes towards and perceptions of the value of technology in the classroom, as well as the strength of the administration's support, are also crucial variables in figuring out how to integrate technology into the

classroom. During the process of incorporating technology into education, a number of challenges could appear. For instance, the literature typically reports on actions, beliefs, knowledge, and skills. (Almaiah et al., 2022).

Knowledge

The study found that teachers' acceptance and usage of IoT in classroom instruction are dependent on their knowledge, beliefs, competence, and institutional support. The results support the correlation between teachers' adoption behavior and their knowledge of technology. According to Yates (2007) as cited in Govender, D. W. (2012), user adoption is the primary reason for IT project failure, rather than technical issues.

Competency

The study by Gökçearslan et al, 2022. found that teachers' competency and IT skills are positively related to their acceptance and use of IOT in education. Teachers must understand how to use various Internet of Things-connected devices for instruction and gain the expertise they need. Teachers' competency has a positive impact on their acceptance behavior, and lower levels of competency lead to minimum technology use. Improved levels of competency can lead to advanced levels of self-assurance in being an effective and competent teacher with technology integration in their teaching practices. In order to successfully integrate technology, one must adopt a comprehensive strategy that goes beyond enhancing teachers' competencies and competence beliefs (Straub, 2009). As 55% of respondents agreed that they have the necessary skills and can easily use ICT in their classroom teaching. However, 44.2% are not capable enough to use connected devices and applications like Google Drive and Google Echo and 5.8% were neutral in this regard. Thus, lower levels of competency in teachers concerning technology led to minimum technology use (Hammond, Reynolds, and Ingram, 2011). On the contrary, improved levels of competency can lead to advanced levels of self-assurance in being an effective and competent teacher with technology integration in their teaching practices (Fanni, Rega, and Cantoni, 2013).

Access

The third hypothesis is supported by previous research that emphasizes the responsibility of institutions to create environments conducive to technology use in teaching. Fraillon et al. found that obstacles to IOT adoption include lack of access, support, and training for instructors, as well as infrastructure issues. This conclusion aligns with research conducted worldwide, where 22% of instructors face access, technical support, and infrastructure issues in adopting this new technology.

The third hypothesis is also supported by the findings from earlier research

investigations, which show that this conclusion emphasizes the responsibilities that institutions must meet in order to create environments that allow teachers to use technology for teaching and learning. According to Fraillon et al. (2014). This study found that major obstacles to instructors adopting IOT include a lack of access to, support for, and training to improve their skills in using this technology, as well as university infrastructure. This conclusion seems to be consistent with other research investigations carried out in various nations throughout the world. As, 22% face a lack of access from administration and technical support, and infrastructure issues to accept and use this new technology.

Perceptions

Moreover, the results of the fourth hypothesis confirm the results of the previous study, as the Technology Acceptance Model, which examines the causal links between perceived usefulness and perceived usability and users' attitudes, intentions, and actual computer adoption behavior, is theoretically based on the Theory of Reasoned Action (Ajzen & Fishbein 1980). (Aldunate & Nussbaum, 2013) The teachers are encouraged to use and benefit from this technology by their positive assessments of its value and effectiveness. Teaching and learning processes are facilitated by teachers' perceptions of technology (Teo et al., 2019). These studies also stressed how instructors' pedagogical views have a big impact on how they teach in the classroom and how they choose practice methods that help students build 21st-century abilities. According to the study's findings, the majority of participants think that using linked devices or IOT applications while teaching can provide them with more advantages.

However, there exists a significant and positive relationship between teachers' perceptions and beliefs for the usefulness of this technology and its acceptance. Study (Ertmer 2005) states that "it is not only the availability of technology that determines if the technology will be used but the teacher's perception of its efficiency". However, 4.3% of the respondents believe that they do not need technology to teach better, and 7% were neutral in showing their beliefs regarding the benefits and usefulness of this technology. Teachers' beliefs and attitudes are significant determinants in knowing their behavior in incorporating technology into teaching activities (Papanastasiou & Angeli 2008). (Aziz & Qureshi, 2018) mentioned that the positive beliefs of teachers lead towards the effective implementation of technology.

RECOMMENDATIONS

Because of ICT, the globe is relatively comfortable right now. Simply because of technology, the teaching and learning process has access to new resources and opportunities. However, integrating technology into classroom activities is a challenge for many teachers (Nikolopoulou & Gialamas, 2016; Javaid & Khokhar, 2016).

Teachers would anticipate integrating computers when they were first brought to schools (Dwyer, Ringstaff, & Sandholtz 1991) if they were enthusiastically taught. Despite growth in these outside resources, teachers' instructional methods remain unchanged (Hadley & Sheingold, 1993).

The impact of potential technological barriers, teachers' perceptions, and competence on their use of technology in teaching and learning has been examined in a number of studies (Muhametjanova & Cagiltay 2016). However, there hasn't been any investigation into the application of IOT technology at the higher education level in Karachi City. Therefore, it has become crucial for the successful adoption of IOT in education to comprehend teachers' perceptions and beliefs about the usefulness of IOT and the key barriers to doing so, as well as how these, along with their competency and access, are related to how they actually use technology in the classroom (Aziz and Qureshi, 2018).

The lack of sufficient statistics addressing the factors influencing teachers' use of IOT in their teaching in Karachi's educational institutions at the higher education level required the problem highlighted by this research study. The results of this research study will give educational researchers some insights into understanding the factors that restrict and delay the deployment of IOT integration in the higher education sector in Karachi city

Contribution to the literature

The IOT eliminates conventional obstacles to teaching and learning and uses smart devices to create robust, hybrid learning environments that also enable students to communicate with professionals from around the globe. Future work will involve the creation of instructional social software within an IOT framework. (Aldowah et al., 2017).

Delimitation of the study

This study has some limitations, including the use of self-reported data, a small sample size, and the exclusion of students as participants. Future research should explore additional data gathering methods, involve a more diverse group of participants, and utilize a qualitative approach. The study's model has a good fit for assessing the acceptability of IoT by higher education professors, but random sampling has some drawbacks. To ensure generalizability of the findings, comparable research should be conducted with a variety of groups.

Recommendations for the Teachers

Teachers should endeavor to embrace change and transition to IOT-connected devices and applications. In order to strengthen their abilities to not just use smart gadgets but

also to integrate and foster teamwork, teachers should start studying and investing in themselves. They should also have a higher moral standard if they want to instruct kids in the twenty-first century.

Recommendations for the University Management

To increase the success of integrating technology into university education, financial support from universities is crucial. Continuous professional development is also necessary to equip educators with new knowledge and abilities. Involving all implementing staff in the design process can create a critical mass of support for the technology implementation. According to the results, nearly 25.3% of educators struggle with advanced technology proficiency, so training programs should be set up to reduce this figure and support technology-integrated teaching and learning practices.

Recommendations for the Policy Makers

A majority of respondents support the integration of IOT in education and believe that teachers should receive ICT training to keep up with technological advancements. The Ministry of Education should invest in IOT infrastructure and provide teachers with training facilities. To develop IOT in Pakistani universities.

Recommendations for the Future Researchers

Further research is needed to determine the acceptability of IoT among students at educational institutions. The potential benefits of incorporating advanced technology like e-real labs, robotics, AI, and gamification into the technology integration matrix in Karachi institutions can also be explored. To gain a deeper understanding of teachers' beliefs, a mixed-methods study can be conducted. The study can also examine how teachers' racial and ethnic backgrounds influence their use of IoT in the classroom. Additionally, specific constructs related to IoT policies and processes can be studied to improve acceptability.

REFERENCES

- Al-Abdullatif, A. M., Al-Dokhny, A. A., & Drwish, A. M. (2022). *Critical Factors Influencing Pre-Service Teachers' Use of the Internet of Things (IOT) in Classrooms*. International Journal of Interactive Mobile Technologies, 16(4). <https://doi.org/10.3991/ijim.v16i04.27007>
- Aldowah, H., Rehman, S. U., Ghazal, S., & Umar, I. N. (2017, September). *Internet of Things in higher education: a study on future learning*. In *Journal of Physics: Conference Series* (Vol. 892, No. 1, p. 012017). IOP Publishing. <https://doi.org/10.1088/1742-6596/892/1/012017>
- Aldunate, R., & Nussbaum, M. (2013). *Teacher adoption of technology*. Computers in
-

- Human Behavior, 29(3), p 519-524. <https://doi.org/10.1016/j.chb.2012.10.017>
- Al-Emran, M., Malik, S. I., & Al-Kabi, M. N. (2020). *A Survey of Internet of Things (IOT) in Education: Opportunities and Challenges*. In *Toward Social Internet of Things (SIOT): Enabling Technologies, Architectures and Applications* (pp. 197-209). Springer, Cham. https://doi.org/10.1007/978-3-030-24513-9_12
- Alkhalefah, H. (2020). *A framework for Industry 4.0 implementation: A case study at King Saud University*. In *Industry 4.0–Shaping The Future of The Digital World* (pp. 52-56). CRC Press. <https://doi.org/10.1201/9780367823085-10>
- Almaiah, M. A., Alfaisal, R., Salloum, S. A., Al-Otaibi, S., Shishakly, R., Lutfi, A., ... & Al-Marouf, R. S. (2022). *Integrating teachers' TPACK levels and students' learning motivation, technology innovativeness, and optimism in an IOT acceptance model*. *Electronics*, 11(19), 3197. <https://doi.org/10.3390/electronics11193197>
- Almetere, E. S., Kelana, B. W. Y., & Mansor, N. N. A. (2020). *Using UTAUT model to determine factors affecting internet of Things acceptance in public universities*. *Int. J. Acad. Res. Bus. Soc. Sci*, 10(2) <http://dx.doi.org/10.6007/IJARBSS/v10-i2/6915>
- Al-Suqri, M. N., & Al-Kharusi, R. M. (2015). *Ajzen and Fishbein's theory of reasoned action (TRA) (1980)*. In *Information seeking behavior and technology adoption: Theories and trends* (pp. 188-204). IGI Global. <https://doi.org/10.4018/978-1-4666-8156-9.ch012>
- Amasha, M. A., Areed, M. F., Alkhalaf, S., Abougalala, R. A., Elatawy, S. M., & Khairy, D. (2020, February). *The future of using Internet of things (IoT) and context-aware technology in E-learning*. In *Proceedings of the 2020 9th International Conference on Educational and Information Technology* (pp. 114-123). <http://dx.doi.org/10.1145/3383923.3383970>
- Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. John Wiley & Sons., Chen, M., Mao, S., & Liu, Y. (2014). *Big data: A survey*. *Mobile networks and applications*, 19, 171-209 <https://firstliteracy.org/wp-content/uploads/2015/07How-Learning-Works.pdf>
- Aziz, F., & Quraishi, U. (2018). *Use of ICT in teaching, professional training, management and personal use: Teachers' Perspective*. *Journal of Arts and Social Sciences*, 1, 115-124. <https://jass.pk/downloads/june-2018/9th07.pdf>
- Banica, L., Burtescu, E., & Enescu, F. (2017). *The impact of internet-of-things in higher education*. *Scientific Bulletin-Economic Sciences*, 16(1), 53-59. http://economic.upit.ro/repec/pdf/2017_1_6.pdf
- Baygin, M., Yetis, H., Karakose, M., & Akin, E. (2016, September). *An effect analysis of industry 4.0 to higher education*. In *2016 15th international conference on information technology based higher education and training (ITHET)* (pp. 1-4). IEEE. <https://doi.org/10.1109/ITHET.2016.7760744>
- Bebell, D., O'Dwyer, L. M., Russell, M., & Hoffmann, T. (2010). *Concerns, considerations, and new ideas for data collection and research in educational technology studies*. *Journal of Research on Technology in Education*, 43(1), 29-52. <http://dx.doi.org/10.1080/15391523.2010.10782560>
- Cennamo, K. S., Ross, J. D., & Ertmer, P. A. (2010) *Assessment and evaluation. Technology integration for meaningful classroom use: A standards-based approach*, 161-188.

- <https://technology-integration-for-meaningful-classroom-use>
- Creswell, J.W. and Creswell, J.D. (2017) *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. 4th Edition, Sage, Newbury Park.
https://www.ucg.ac.me/skladiste/blog_609332/objava_105202/fajlovi/Creswell.pdf
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). *User acceptance of computer technology: A comparison of two theoretical models*. *Management science*, 35(8), 982-1003. <https://www.jstor.org/stable/2632151>
- Dwyer, D. C., Ringstaff, C., & Sandholtz, J. H. (1991). *Changes in teachers' beliefs and practices in technology-rich classrooms*. *Educational leadership*, 48(8), 45-52.
https://files.ascd.org/staticfiles/ascd/pdf/journals/ed_lead/el_199105_dwyer.pdf
- Educause 2016 Online. <https://er.educause.edu/articles/2016/6/the-internet-of-things-is-here>
- Eisenberg, M. B., & Johnson, D. (1996) *Computer Skills for Information Problem-Solving: Learning and Teaching Technology in Context*. ERIC Digest.
<https://files.eric.ed.gov/fulltext/ED465377.pdf>
- Ertmer, P.A. Teacher pedagogical beliefs: *The final frontier in our quest for technology integration?*. *ETR&D* 53, 25–39 (2005). <https://doi.org/10.1007/BF02504683>
- Fisk, P. (2017). *Education 4.0 ... the future of learning will be dramatically different, in school and throughout life*. <http://www.thegeniusworks.com/2017/01/future-education-young-everyone-taught-together>
- Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Gebhardt, E. (2014). *Preparing for Life in a Digital Age - The IEA International Computer and Information Literacy Study International Report*. Heidelberg, New York, Dordrecht, London: Springer International Publishing. <https://doi.org/10.1007/978-3-319-14222-7>
- Frick, T. W. (1989). *Bayesian adaptation during computer-based tests and computer-guided practice exercises*. *Journal of Educational Computing Research*, 5(1), 89-114.
<https://doi.org/10.2190/60HH-77DG-WK36-PG4300>
- Ghavifekr, S., Kunjappan, T., Ramasamy, L., & Anthony, A. (2016). *Teaching and Learning with ICT Tools: Issues and Challenges from Teachers' Perceptions*. *Malaysian Online Journal of Educational Technology*, 4(2), 38-57.
<https://files.eric.ed.gov/fulltext/EJ1096028.pdf>
- Gökçearslan, Ş., Yıldız Durak, H., & Atman Uslu, N. (2022). *Acceptance of educational use of the Internet of Things (IOT) in the context of individual innovativeness and ICT competency of pre-service teachers*. *Interactive Learning Environments*, 1-15.
<https://doi.org/10.1080/10494820.2022.2091612>
- Goodyear, P., Jones, C., Asensio, M., Hodgson, V. and Steeples, C. (2005) *Networked Learning in Higher Education: Students' Expectations and Experiences*. *Higher Education*, 50, 473-508. <https://doi.org/10.1007/s10734-004-6364-y>
- Govender, D. W. (2012). *A model to predict educators' attitudes towards technology and thus technology adoption*. *Africa Education Review*, 9(3), 548-568..
<https://doi.org/10.1080/18146627.2012.741101>
- Graham, R. C., Burgoyne, N., Cantrell, P., Smith, L., St Clair, L., & Harris, R. (2009). *Measuring the TPACK confidence of inservice science teachers*. *TechTrends*, 53(5), 70-79. <http://dx.doi.org/10.1007/s11528-009-0328-0>
- Hadley, M., & Sheingold, K. (1993). *Commonalities and distinctive patterns in teachers'*

- integration of computers*. American journal of education, 101(3), 261-315.
<https://www.learntechlib.org/p/146930/>.
- Hammond, M., Reynolds, L., & Ingram, J. (2011). *How and why do student teachers use ICT?*. Journal of Computer assisted learning, 27(3), 191-203.
<https://doi.org/10.1111/j.1365-2729.2010.00389.x>
- Hu, Z., Yang, Z., Salakhutdinov, R., & Xing, E. (2016, November). *Deep neural networks with massive learned knowledge*. In Proceedings of the 2016 Conference on Empirical Methods in Natural Language Processing (pp. 1670-1679).
<http://dx.doi.org/10.18653/v1/D16-1173>
- Ionescu-Feleaga, L., Ionescu, B. Ş., & Bunea, M. (2021). *The IOT technologies acceptance in education by the students from the economic studies in Romania*. Amfiteatru Economic, 23(57), 342-359. <http://dx.doi.org/10.24818/EA/2021/57/342>
- Javaid, S., & Khokhar, A. J. (2016, August). *Students and Teachers Perceptions of ICT Use in Classroom: Pakistani Classrooms*. In The Asian Conference on Technology in the Classroom 2016: Official Conference Proceedings (pp. April-28). The International Academic Forum.) <http://dx.doi.org/10.17613/ng24-r681>
- Keengwe, J., Kidd, T., & Kyei-Blankson, L. (2009). *Faculty and technology: Implications for faculty training and technology leadership*. Journal of Science Education and Technology, 18, 23-28. <http://dx.doi.org/10.1007/s10956-008-9126-2>
- Kent, A.M., & Giles, R.M. (2017). *Preservice Teachers' Technology Self-Efficacy*. SRATE Journal, 26, 9-20. <https://files.eric.ed.gov/fulltext/EJ1134392.pdf>
- Kersaint, G. (2003). *Technology beliefs and practices of mathematics education faculty*. Journal of Technology and Teacher Education, 11(4), 549-577.
<https://www.learntechlib.org/primary/p/2222/>.
- Kiryakova, G., Yordanova, L., & Angelova, N. (2017). *Can we make Schools and Universities smarter with the Internet of Things?* TEM Journal, 6(1), 80.
<http://dx.doi.org/10.18421/TEM61-11>
- Kiryakova, G., Angelova, N., & Yordanova, L. (2018). *The potential of augmented reality to transform education into smart education*. TEM Journal, 7 (3), 556–565. ,
<https://doi.org/10.30935/cedtech/10866>
- Knezek, G., Christensen, R. (2008). *The Importance of Information Technology Attitudes and Competencies in Primary and Secondary Education*. In: Voogt, J., Knezek, G. (eds) International Handbook of Information Technology in Primary and Secondary Education. Springer International Handbook of Information Technology in Primary and Secondary Education, vol 20. Springer, Boston, MA.
https://doi.org/10.1007/978-0-387-73315-9_19
- Koehler, M., & Mishra, P. (2009). *What is technological pedagogical content knowledge (TPACK)?*. Contemporary issues in technology and teacher education, 9(1), 60-70.
https://www.researchgate.net/publication/241616400_What_Is_Technological_Pedagogical_Content_Knowledge
- Lawless, K. A., & Pellegrino, J. W. (2007). *Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers*. Review of educational research, 77(4), 575-614.
<https://doi.org/10.3102/0034654307309921>
- Lee, M. K., Cheung, C. M., & Chen, Z. (2005). *Acceptance of Internet-based learning*

- medium: the role of extrinsic and intrinsic motivation*. Information & management, 42(8), 1095-1104. <https://doi.org/10.1016/j.im.2003.10.007>
- Li, Nai (2002). *Culture and gender aspects of students' information searching behaviour using the Internet : a two-culture study of China and the UK*. PhD thesis The Open University. <https://doi.org/10.21954/ou.ro.0000fbdd>
- Majeed, A., & Ali, M. (2018, January). *How Internet-of-Things (IOT) making the university campuses smart? QA higher education (QAHE) perspective*. In 2018 IEEE 8th Annual Computing and Communication Workshop and Conference (CCWC) (pp. 646-648). IEEE.). <http://dx.doi.org/10.1109/CCWC.2018.8301774>
- Marquez, J., Villanueva, J., Solarte, Z., & Garcia, A. (2016). *IoT in education: Integration of objects with virtual academic communities*. In New advances in information systems and technologies (pp. 201-212). Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-31232-3_19
- Mathews, S. P., & Gondkar, R. R. (2017). *Solution integration approach using IOT in education system*. International Journal of Computer Trends and Technology, 45(1), 45-49.). <http://dx.doi.org/10.14445/22312803/IJCTT-V45P109>
- Meacham, S., Stefanidis, A., Gritt, L., & Phalp, K. T. (2018). *Internet of Things for education: Facilitating personalised education from a university's perspective*. <https://www.researchgate.net/publication/325659343>
- Mian, S. H., Salah, B., Ameen, W., Moiduddin, K., & Alkhalefah, H. (2020). *Adapting universities for sustainability education in industry 4.0: Channel of challenges and opportunities*. Sustainability, 12(15), 6100. <https://doi.org/10.3390/su12156100>
- Mishra, P., & Koehler, M. J. (2006) Technological pedagogical content knowledge: A framework for teacher knowledge. Teachers college record, 108(6), 1017-1054, <http://dx.doi.org/10.1111/j.1467-9620.2006.00684.x>
- Moraes, E. B., Kipper, L. M., Hackenhaar Kellermann, A. C., Austria, L., Leivas, P., Moraes, J. A. R., & Witczak, M. (2022). *Integration of Industry 4.0 technologies with Education 4.0: Advantages for improvements in learning*. Interactive Technology and Smart Education. <http://dx.doi.org/10.1108/ITSE-11-2021-0201>
- Muhametjanova, G., & Cagiltay, K. (2016). *Integrating technology into instruction at a public university in Kyrgyzstan: Barriers and enablers*. Eurasia Journal of Mathematics, Science and Technology Education, 12(10), 2657-2670.) <https://doi.org/10.12973/eurasia.2016.1287a>
- Nair, I., & Das, V. M. (2012). *Using Technology Acceptance Model to assess teachers' attitude towards use of technology as teaching tool: A SEM Approach*. International Journal of Computer Applications, 42(2), 1-6. <http://dx.doi.org/10.5120/5661-7691>
- Nicolle, P.S., Lou, Y. (2008). *Technology Adoption Into Teaching and Learning by Mainstream University Faculty: A Mixed Methodology Study Revealing the How, When, Why, and Why Not*. Journal of Educational Computing Research, 39 (3), 235-265 <https://doi.org/10.2190/EC.39.3.c0>
- Nikolopoulou, K., & Gialamas, V. (2016). *Barriers to ICT use in high schools: Greek teachers' perceptions*. Journal of Computers in Education, 3, 59-75. <http://dx.doi.org/10.1007/s40692-015-0052-z>
- Papanastasiou, E. C., & Angeli, C. (2008). *Evaluating the use of ICT in education: Psychometric properties of the survey of factors affecting teachers teaching with*

- technology* (SFA-T3). *Journal of educational technology & society*, 11(1), 69-86.
https://www.researchgate.net/publication/220374660_Evaluating_the_Use_of_ICT_in_Education
- Pei, X. L., Wang, X., Wang, Y. F., & Li, M. K. (2013). *Internet of things based education: Definition, benefits, and challenges*. *Applied Mechanics and Materials*, 411, 2947-2951. <http://dx.doi.org/10.4028/www.scientific.net/AMM.411-414.2947>
- Pervez, S., ur Rehman, S., & Alandjani, G. (2018). *Role of Internet of Things (IOT) in Higher Education*. In 4th International Conference on Advances in Education and Social Sciences (pp. 792-800). https://www.ocerints.org/adved18_e-publication/papers/216.pdf
- Putjorn, P., Ang, C. S., & Farzin, D. (2015, May). *Learning IOT without the "I"-Educational Internet of Things in a Developing Context*. In Proceedings of the 2015 Workshop on Do-it-yourself Networking: An Interdisciplinary Approach (pp. 11-13). <https://doi.org/10.1145/2753488.2753489>
- Rogers, E.M. (1995). *Diffusion of Innovations: Modifications of a Model for Telecommunications*. In: Stoetzer, MW., Mahler, A. (eds) *Die Diffusion von Innovationen in der Telekommunikation*. Schriftenreihe des Wissenschaftlichen Instituts für Kommunikationsdienste, vol 17. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-79868-9_2
- Scherer, R., Siddiq, F., & Tondeur, J. (2019) *The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education*. *Computers & Education*, 128, 13-35.). <https://doi.org/10.1016/j.compedu.2018.09.00>
- Straub, E. T. (2009). *Understanding Technology Adoption: Theory and Future Directions for Informal Learning*. *Review of Educational Research*, 79(2), 625-649. <https://doi.org/10.3102/0034654308325896>
- Talwana, J. C., & Hua, H. J. (2016, December). *Smart world of Internet of Things (IOT) and its security concerns*. In 2016 IEEE international conference on internet of things (iThings) and IEEE green computing and communications (GreenCom) and IEEE cyber, physical and social computing (CPSCom) and IEEE smart data (SmartData) (pp. 240-245). IEEE. <https://doi.org/10.1109/iThings-GreenCom-CPSCom-SmartData.2016.64>
- Teo, T., Fan, X., & Du, J. (2015). *Technology acceptance among pre-service teachers: Does gender matter?* *Australasian Journal of Educational Technology*, 31(3) <https://doi.org/10.14742/ajet.1672>
- Teo, T., Sang, G., Mei, B., & Hoi, C. K. W. (2019). *Investigating pre-service teachers' acceptance of Web 2.0 technologies in their future teaching: a Chinese perspective*. *Interactive Learning Environments*, 27(4), 530-546. <https://doi.org/10.1080/10494820.2018.1489290>
- Tianbo, Z. (2012, November). *The internet of things promoting higher education revolution*. In 2012 Fourth International Conference on Multimedia Information Networking and Security (pp. 790-793). IEEE.). <http://dx.doi.org/10.1109/MINES.2012.231>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). *User acceptance of information technology: Toward a unified view*. *MIS quarterly*, 425-478.). <https://doi.org/10.2307/30036540>

-
- Wang, L., Ertmer, P. A., & Newby, T. J. (2004). *Increasing preservice teachers' self-efficacy beliefs for technology integration*. Journal of research on technology in education, 36(3), 231-250 <http://dx.doi.org/10.1080/15391523.2004.10782414>
- Yildiz Durak, H. (2019). *Examining the acceptance and use of online social networks by preservice teachers within the context of unified theory of acceptance and use of technology model*. Journal of Computing in Higher Education, 31(1), 173-209. <https://link.springer.com/article/10.1007/s12528-018-9200-6>
- Zaerov, E., Letskovska, S., Seymenliyski, K., & Simionov, R. (2020, October). *PV System Monitoring by IOT in Smart University*. In Proceedings of the 9th International Conference on Telecommunications and Remote Sensing (pp. 44-49). <http://dx.doi.org/10.1145/3430116.3430124>