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# Diffusion of the Information and Communication Technologies in Education, Perspectives and Limitations

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## Abstract

This research study is undertaken in order to explain the unexpectedly slow rate of ICT diffusion in education. Recent and prior research literature for ICT in education has been evaluated to answer the four questions which have been stated by Rogers for the individual users of innovation. Our findings show that despite the obvious benefits of ICT for the potential users in educational contexts, the adoption of ICT requires a deep focus on the teachers' and students' needs as well as the barriers to ICT diffusion in education. Also, we consider that the relevant research studies confirm the critical role of teachers and students in the efficient implementation of innovative technological tools in the educational process.

## Keywords

Information and Communication Technology, Innovation Diffusion, ICT Adoption in Education

## 1. Introduction

Rogers (2003) defined innovation as an idea, practice, or object which was recognized as new by individuals or teams. Also, he mentioned that the words "innovation" and "technology" have often been considered synonyms. However, the fact that many innovations are technological does not mean that those two words have the same meaning. Rogers is known for his particularly significant contribution to the development of the innovation's diffusion theory. He also examined the adoption and spread of technology in society.

It is widely accepted that various technological achievements have been identified as innovations. In this sense, information communication technology is an innovation since it has been developed and implemented in the new era of education. Rogers noted that technology has two components: the hardware aspect and the software aspect. Looking into the ICT educational applications we can notice hardware and software infrastructure which is available in schools. Nevertheless, Rogers mentioned that although many technologists expect that beneficial innovations, such as technology, will be spread easily and quickly, the rate of diffusion becomes disappointingly slow. Aivazidi and Michalakelis (2021) detected poor implementation of the ICT technology in primary education even during the period of the Covid pandemic. Although the adoption of the ICT became mandatory during that period, the use of e-learning available tools has been considered unexpectedly limited. As a matter of fact, we can assume that the obvious benefits technologists attribute to the innovations are not so clear

to the potential adopters. However, Rogers explained that the individual user of innovation usually states four questions. 1) What is innovation? 2) How does it work? 3) What are the innovation consequences? and 4) Which are the advantages and disadvantages of that specific innovation?

Due to the fact that the ICT constituted an innovation for the educational process, we explore the research literature to detect answers to those 4 questions. More specifically, we detect the factors which will contribute to the more rapid adoption and implementation of ICT in education and especially in primary schools. During the era of the Covid-19 pandemic, the use of ICT applications became mandatory. Nonetheless, recent studies by Aivazidi and Michalakelis (2021), Tkachuk et al. (2021), and Amate et al. (2021) found evidence that the implementation of various ICT applications, such as the use of e-class platforms and the use of computers, was not as wide as had been expected. Moreover, it is noteworthy that relevant studies identified teachers as the most important stakeholders with a critical role in the diffusion of ICT. Of course, the equally important role of decision-makers, parents, and students cannot be ignored. In this study, we examine both the recent and previous literature to detect any differences in the research findings for the diffusion of ICT in education and specifically during the Covid-19 period. In this way, we contribute to the research literature and develop a framework for further research.

This research paper is organized as follows: In the next section, we will focus on the relevant research literature to the four questions raised by Rogers. The research questions, the methodological approach, and our findings are discussed in the third section of our study and we will conclude by mentioning the limitations of our findings and suggestions for future research.

## **Searching the Research Literature**

### *What is Innovation-ICT and how does it work?*

Rogers (2003) noted the hardware and software aspects constitute the two main components of technology. Naresh (2020) considers the television, mobile phones, radio, desktops and laptops, projectors, digital cameras, DVDs and CDs, printers and scanners, tablets and pen drivers, online, and interactive whiteboards, smartboards and e-readers to be ICT educational tools. All of them are modern and traditional hardware infrastructures which became necessary for the development of innovative educational methods based on ICT. Cochrane (2016) discussed innovative teaching using virtual reality devices and explained that those devices needed the relevant software and internet platforms to support smart education and the digital applications which have been embodied in the teaching process.

In addition, Assar (2015) explored the relevant prior literature, identified three categories of ICT artifacts which could be included in modern teaching. 1) The digital learning material (Polsani, 2006) which could be internet hosted video, illustrations, simulation and interactive assessment tools (Kreijns et al., 2013). 2) The general tools which support the diffusion of 2019. In the same direction, Davies and West (2014) supported that the educational technology consists of any kind of tool, equipment and mechanical or digital device that help students and

teachers to achieve their learning goals. Moreover, they consider that the learning and instructional technologies constitute the educational technology which could be recognized as successful on condition that it accomplishes the expected learning outcome.

According to the research literature, it is confirmed that the previous papers view ICT as a technologically tangible asset (e.g. Computers, DVDs, cameras, smart boards) Polsani (2006), Kirschner and Selinger (2003), which can satisfy the learning needs in the classroom rather than as intangible applications for distance learning development. However, the continuous upgrading of internet's infrastructure and the development of more sophisticated devices led to more intelligent educational applications, based on mobile technologies.

Over the last two decades the rapid evolution of the Internet of Things (IoT) technology contributed to the development of Smart Education. The IoT has also been named as Internet of Everything (Lee & Lee, 2015) and it has been described as a new technology paradigm. IoT links objects in a network anywhere, anytime and also connects people with them. Using IoT three types of networking could be achieved according to Basset et al. (2018): 1) people to people 2) people to things 3) things to things via internet connection. Lee and Lee (2015) noted that the hardware and software technology that is needed for the efficient use of IoT could be categorized in radio frequency identifications, wireless sensor networks, middleware, cloud computing and IoT appropriate software. Basset et al. (2018) considered that smart education was based on the IoT and referred to IoT applications which are relevant to the smart learning environment, such as smart digital boards, mobile devices and tablet educational applications, electronic books, and online learning sources. They also explained that a smart learning environment requires digital and physical equipment, IT infrastructure, workplace architecture and learning methods.

The implementation of ICT in education could make teaching easier without reducing the teaching effort (Penalvo et al., 2020). However, Raja and Nagasubramani (2018) supported that using ICT, students could easily search for assisting material which could enable them to cover their teaching heels and improve their learning. Furthermore, they stated that the use of technology led to the increase of online degrees.

Dake and Ofosu (2019) explained how the 5G integrated technologies work in a smart learning environment. As they noted, using the 3d virtualization technology the computers produce more realistic images. In this way, the students have a better sense of the learning material and can understand it better than read it in a book. Moreover, the cloud computing offers users the ability to store and use applications from different devices and servers. In addition, the implementation of augmented and virtual reality develops haptic environment where the learners can perceive whatever is included in the simulated environment in a multisensory way. Virtual and hybrid virtual classes could be developed with this technology. In these classes, students can be in the classroom environment. An extended and holistic approach of the networking using virtual reality is the Tactile internet. Tactile Internet empowers and promotes the interaction within human and machine.

Concluding, it can be claimed that ICT implementation in the educational process offers learners and teachers the opportunity to work and learn using new methods and prospecting

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an integrated learning outcome regardless of whether it takes place in a smart learning environment or a simple classroom with the appropriate infrastructure.

It is commonly accepted that teachers and students are the potential users of ICT in education. Also, they have been recognized as the key role players for the adoption and implementation of ICT in the learning process (Ha & Lee, 2019; Barber & Mourshed, 2007). Thus, it is crucial that users realize the effect of ICT on the educational process and be aware of the advantages and disadvantages for the users for the diffusion of ICT.

Tinio (2002) stated that the learning process became more active, collaborative, creative, integrative and evaluative using ICT. According to Rogers' Diffusion of Innovation theory, increased access to digital technology and technical support, appropriate teacher training, supply of the necessary equipment to teachers and students, the main stakeholders in education are the prerequisite for the efficient adoption of ICT in education (Kiugu et al., 2021). It seems to be widely accepted that the import of ICT in the learning process became an innovation which offered educators and learners a new opportunity of learning and created a new educational environment (Whiteside, 2011).

As Jain (2021) and Raja and Nagasubramani (2018) explained, teaching and learning do not have geographical limitations as was the case in the past. In the new educational environment, courses can be delivered via distance learning methods which are based on ICT. Therefore, anyone can study without abandoning the advantages of home staying. Time and space no longer constitute restrictive limits for education's stakeholders, since the introduction of information technology in the teaching process and a new era of globalized integrated communication, exchanging ideas and improving the exploration of available resources has been raised (Veiga & De Andrade, 2021). During this era smarter learning ecosystems have been developed, in which it is expected that the life of learners and teachers will be easier (Tinoco-Giraldo et al., 2020). As Penalvo et al. (2020) noted this does not mean less teaching effort but the improved learning outcome using the Internet of Things (I.o.T.) application and adopting the digital transformation.

The I.o.T. contributed to the development of the Smart Educational System which needs a smart learning environment in order to offer smart education based on the Smart Pedagogy and using the Knowledge technology (Omar & Obaid Alnaqbi, 2020). I.o.T. also contributed to the transformation of mobile phones, tablets and other devices, which were not designed for educational purposes to smart education tools formulating an intelligent, dynamic educational system (Dake & Ofosu, 2019). As a result of the smart education with the support of 5G technology, Dake and Ofocu (2019) noticed the new learning needs and also the revolutionary learning applications such as the augment and virtual reality tools which can create learning environment combining the physical and digital distance presence of tutors and learners. We must note that appropriate hardware and software infrastructure is a prerequisite for the implementation of smart technology in education. Thus, among the consequences of the ICT in education we should add not only the creation of a new educational environment but also the orientation to the necessary technological equipment (Raja & Nagasubramani, 2018). This equipment could contain I.o.T.

neurosensory devices, digital storages, boards and display, Wi-Fi sensors for classroom management and the provision of environmental information and control (Basset et al., 2018).

As Gros (2016) stated, in addition to the improvement of the teaching process, smart learning should focus on personalization, adopting the learning activity to the needs of any individual learner. To the same direction, Assar (2015) explained that ICT transformed traditional education providing face to face courses and introducing adaptive learning systems oriented to learners' profiles.

Previous research studies placed more emphasis on information management as a significant effect of ICT in education. Specifically Dance (2010) observed that ICT users can collect, organize and integrate educational information. In advance they can create new information, evaluate the existing and new one and present that information using multimedia tools. Nevertheless, ICT affected users providing them with the skills to exchange information, evaluate, modify their work and improve its quality.

Although the I.o.T. and smart education were not developed in the first decade of the twenty first century, previous researchers claimed, according to Webb and Cox (2004), the diffusion of ICT will provide integrated pedagogy opportunities and will transform the teaching and learning process (Cornu, 1995; Hawkrigde, 1990) to a more collaborative Yelland (2002) and interactive (Hennesy & Osborne, 2003) one.

According to prior and recent research literature, we found evidence that ICT adoption has a significant impact on the learning process and structure. Traditional education becomes more personalized and students can follow courses without leaving their houses. A new more dynamic and intelligent learning system has been developed applying ICT and smart education systems. In addition, the needs for the necessary improvement of the existing infrastructure have been increased as a consequence of the implementation of digital technology in the learning process.

However, the diffusion of ICT requires the appropriate training and skills of the teachers and their intention to use them. The increase of distance learning programs has been identified as an effect of ICT diffusion in education, which is now more reactive and communicative than it used to be before. Concluding, we realize that ICT has a significant impact on the educational process. Nevertheless, searching the relevant research literature we detect the advantages and disadvantages of ICT adoption in education, which are described in the following section.

### *Advantages and Disadvantages*

Roger's Diffusion of Innovation Theory states that the users of innovation should know its advantages and disadvantages in order to adopt it. It is common knowledge that educators and learners are the key stakeholders in the learning environment.

Dance (2010) explained that using ICT students will be able to select, interpret and test information, increase their efficiency and communication skills, become more creative and build self confidence and independence. In a more specialized study focused on software for mathematics, Clements (2000) found that the pupils who applied ICT for learning purposes

in Mathematics acquired more skills in understanding and analyzing geometrical concepts, obtained high level of geometric and mathematical thinking, handled ratio and proportion concepts better, could more efficiently solve mathematical problems and developed more interactive behavior. The better communication skills were also specified by Kirschner and Davis (2003) who observed the increase of students' ability to implement ICT for improved communication both within student groups and with teachers. They also noticed that learners who use ICT, continue their studies even if they have completed them for their learning and needs assessment. Moreover, ICT helps learners to meet their needs and increase their self-efficacy having high quality digital learning material (Kirschner & Selinger, 2003).

In more recent studies, ICT has been reflected to smart technologies, which offer more opportunities to learners. Tissenbaum and Slotta (2019) focused on the smart classroom in which students have a more active role than in the typical classroom. Specifically, they do not passively collect information but they are able to create and transfer data within different locations. In this way, according to Raja and Nagasubramani (2018), students become more motivated to learn, acquiring ICT skills which will be useful to them in their future working place.

The afore mentioned researchers highlighted the contribution of ICT in the green revolution, due to the fact that using ICT equipment, students need less paper for photocopies, thereby saving their money. Basset et al. (2018) agreed with the recent and prior researcher's presented advantages regarding the environmental benefits, the communicative advantages and the improvement of students' creativity and excitement using ICT in their learning process and they add that all the I.o.T. devices such as cameras, sensors, monitoring devices, devices' warnings, increase the level of students' safety and security. We should mention, moreover, that during the period of Covid-19 pandemic, ICT educational applications allowed students to participate in the learning process as much as possible.

As expected, the sudden mandatory implementation of ICT in education for the distance learning purposes became a challenge for teachers who also have a crucial role in the educational process. Of course, under the critical conditions of the Covid-19 period, teachers seem to use the technology, but this does not mean that they have adopted it (Aivazidi & Michalakelis, 2021). As Rogers has already proposed since 2003, we consider it is of utmost importance that teachers first understand the advantages of ICT use in education.

Naresh (2020) observed that ICT can be the tool for teachers to implement innovative practices and promote the learning outcome. Penalvo et al. (2020) note that teaching could be easier using ICT and therefore this will contribute to the improvement of the learning outcome. The findings of the recent literature are consistent with those of the previous studies in which the benefits of ICT for teachers involve the development of modern teaching skills and collaboration among themselves and with the students in both asynchronous and synchronous educational environments. Thus, they can provide a more effective teaching using appropriate hardware and software tools in the classroom or outside of it.

Internet development in the last decade of the previous century has undoubtedly proven

critical for the dissemination of learning support material to teachers providing them with the necessary tools for the new era of education (Davis, 1997). Kirschner and Sellinger (2003) stated that ICT can be useful to them for their professional development and it is more than a working tool. Furthermore, they consider that the teachers who adopt and implement modern learning technologies will be positively affected by the improvement of the learning outcome.

Skinner and Preece (2003) point out that teachers can save much more time if they download teaching material in their computer than use hardcopies, books or Journals and they then have the ability to modify it according to their personal needs. Of course, they can save money and protect the environment if they don't print the material. In their research they also find that teachers who have used specific digital material enhanced their understanding of the topics of their science.

Looking into the research literature we observe that the use of ICT in education has been related to many benefits for learners and educators. Nevertheless, there are disadvantages, limitations and borders of ICT diffusion which have been reported in the recent and prior research studies. Although Calabuig et al. (2018) consider that their effects of ICT on students have not been adequately studied, we observe in previous studies that they mention negative impact of the extensive use of computers. Specifically, Ates (2013) focuses on the students' physical and psychological health problems. More specifically, he mentions problems with the students' eyes, muscle growth, food preferences, weight control and their exposure in radiation. Hyperactivity, lack of attention in the classroom, limited use of language and socialization have been referred as psychological negative effects of the long-term use of digital communication devices. Ates (2013) concludes that parental and teacher supervision and control are necessary for the limitation of the problems which can be caused by ICT implementation in the learning procedure. In a prior study, Piotrowski et al. (2009) detect that cheating seems to be easier online for students. Davies and West (2014) present previous research in which Jager and Brown (2010) have indicated that ICT offers more opportunities to students for cheating and plagiarism. Raja and Nagasubramani (2018) point that in addition to cheating, ICT use may negatively affect students' concentration and writing skills. In particular, children have problems with the spelling of many words and the proper use of grammar. In addition, lack of students' concentration has been detected, since it is easy for them to play with their cell phones or chat during the lecture. Raja and Nagasubramani (2018) also consider that ICT limits students' imagination and creativity.

### **3. Research and Synthesis**

#### **3.1. Research Question and Methodological Issues**

The purpose of this paper is to examine the factors which affect ICT diffusion rate. Assuming that ICT constitutes an innovation in the educational process and based on Roger's four questions regarding the potential users of ICT in education, we have stated the following research questions:

- 1) What is ICT in the education and how it works?

2) Which are the consequences in education from the adoption of ICT and which are the advantages and the disadvantages ICT implementation?

We also assume that the most important users of ICT in education are teachers and learners.

In order to answer the research questions raised, we conduct a systematic review of the relevant research literature (Xiao & Watson, 2019). Popay et al. (2006) and Lucas et al. (2007) proposed the textual narrative synthesis to organize the literature review in homogenous subgroups and search for common or different views across the reviewed studies.

In the previous sections of this study we presented the prior relevant research studies which provided answers to the research questions. In the following section we approach the questions making a narrative synthesis based, on the one hand, on the most common barriers of the ICT adoption, and on the other, on the assumption that teachers and learners are the most important potential users of ICT in education.

### *Consequences of the ICT in the Education.*

#### **3.2. Discussion-Synthesis**

Based on the examined research studies, we consider that ICT implementation may contribute to the learning process albeit the negative effect on students must be taken into consideration. As it has been already stated, teachers also have a crucial role in education, besides learners (Barber & Mourshed, 2007). None ICT diffusion is possible without the contribution of educators, due to the fact that educators are less familiarized with ICT than learners (Palfrey & Gasser, 2008). More resistance to ICT adoption will be expected from teachers. As a matter of fact, teachers' studies have not been based on ICT and consequently they have been taught courses during their studies without the use of the digital tools (Lankshear & Knobel, 2003). On the other hand, we must notice that many of them participated in training seminars on the use of technology in the educational process. However, this does not mean that they are able to use it in the class and further on their teaching activity. The transition to the implementation of modern teaching methods based on ICT requires teachers' positive attitude, but as Gressard and Loyd (1985), observed, lack of time, necessary experience, preparation, support and appropriate infrastructure have been reported as barriers of ICT diffusion (Gressard & Loyd, 1985; Pelgrum, 2001; Evers et al., 2002). Assar (2015) presents surveys which highlighted the limited use of digital learning tools on the teaching efficiency (Smeets, 2005; Mahdizadeh, 2008).

Cohen and Ball (2006) believe that lack of motivation explains the lack of teachers' interest in the adoption and implementation of new technologies in the educational process. Michalakelis and Aivazidi (2021) concluded that the teachers' exhaustion and the resistance to innovation due to the stress caused by the "change" become barriers for the adoption of any innovation in education. Aivazidi and Michalakelis (2021) observed that the mandatory implementation of ICT does not lead to a high-level ICT adoption. Moreover, Jimmoyannis and Komis (2007) mentions that teachers are not convinced that ICT solely



have a positive impact on the educational process and they believe that the extensive use of ICT can decrease students' social interaction.

The above studies show that the implementation of ICT in education is a complicated project and many factors must be taken into consideration for its efficient use in the learning process. Teachers don't seem ready to fully accept and adopt ICT. On the other hand, the intensive and without limits use of ICT can cause problems to students. In other words, both of the potential users of ICT in education need to be treated properly in order, not only to accept, but also contribute to the effective use of digital technologies in education.

#### *Further Discussion*

This study is focused especially in the following questions 1) What is ICT in education 2) How it works c. Which are the consequences if ICT in education and d. Which are the advantages and disadvantages of the implementation of ICT in the educational process. Furthermore, we detected the factors which can hinder ICT diffusion in the learning activities. The above questions are stated to answer the main research question of this paper which has been stated by Rogers (2003). Specifically, he observed that the diffusion rate of ICT is lower than the development rate respectively. Following Roger's methodology, we explore the relevant research literature to answer the questions he stated in order to detect the factors which are related to the delay of ICT diffusion in education.

According to the examined literature, ICT consists of the tangible and in- tangible technology, which is needed for the implementation of ICT in educa- tion, the learning management systems and the digital learning material. The technological evolution offers significant opportunities for the development of a modern learning environment, in which an improved learning outcome is ex- pected. The more recent ICT in education literature focuses on the Internet of Things applications in the learning process and on the development of a smart learning environment. However, the technological evolution contributes to the development of distance learning more than in prior periods. The findings of the studies which describe the technological application in education, the modern learning environment, the expected teaching outcome and the distance learning existing and upcoming opportunities are consistent with the optimistic expecta- tion of the rapid implementation of ICT in education.

Nevertheless, the consequences of ICT and its advantages and disadvantages seem to be the key that explain the slow rate of ICT diffusion. Looking into the relevant literature we observe that teachers and learners are the key role players for the adoption and implementation of ICT. According to the recent studies present in the previous sections, both of the users of the educational technology have common interests from ICT. Time and space no longer constitute restric- tive limits for the diffusion of knowledge. The teaching procedure becomes more efficient and personalized and the learning environment friendlier to learners, who are familiarized with technology. Moreover, the required teaching effort can be less than in the past without any reduction in the quality of the educational process. Contrary wise the learning outcome is expected to be improved. The more effective classification, management and integration of the learning ma- terial are also included in

the benefits for teachers and students. On the other hand, despite the obvious benefits for users, ICT adoption in education does not seem to be as fast as expected.

Prior and recent studies note that teachers show cautiousness regarding ICT implementation in the teaching process. Since they have not been familiarized with ICT and without any tangible motives, the teachers appeared reluctant to the use of ICT in the classroom or application of ICT in distance learning. Inadequate training, lack of time and of the sometimes appropriate infrastructure become significant barriers and explain the limited interest of teachers for ICT educational applications. Furthermore, according to the prior research findings presented in the previous sections of this study, the change causes stress which is related to teachers' exhaustion and their resistance to ICT based teaching methods.

However, there are studies that demonstrate the negative effects of ICT interactive use on the student's psychology, physical health, concentration communication, and socialization. In addition to these disadvantages, they point out cheating and plagiarism as well as insufficient knowledge of grammar and dictation rules. Moreover, the limitation of students' imagination and creativity has been considered as an ICT disadvantage for learners.

#### **4. Conclusion**

This study has been undertaken to detect the causes of the slow implementation of ICT in education, even during the period of the Covid-19 pandemic. For this purpose, we follow Roger's approach since he has stated four questions in order to explain the low rate of technological innovation diffusion. Assuming that ICT implementation in education is related to the technological innovation in the educational process, we selected prior and recent studies that provide answers to Roger's questions. Although the obvious benefits of ICT show that its faster adoption by learners and teachers can be expected, there are many prerequisites for it. On the other hand, there is evidence that the rate of ICT diffusion is different within the countries. Due to the fact that the technological infrastructure, educational environment, teacher training opportunities, and social and economic characteristics are not the same in each country, we believe that individual empirical research studies at a country level are necessary to detect the barriers to ICT adoption.

Thus, future research can evaluate the role of teachers and students in ICT diffusion in education and find evidence to explain the low rate of ICT implementation in education even during the period of the mandatory use of ICT during the Covid-19 pandemic. This study is based on Roger's approach for the explanation of the low innovation diffusion rate and this constitutes a limitation of the study. However, in an extended approach of empirical research, the stakeholders of education can contribute with more questions that must be answered by ICT users. Last but not least, we believe that this study also contributes to the research literature by studying and analyzing more recent research studies in order to examine Roger's questions which have been started since the beginning of the entire century.

#### **Conflicts of Interest**

The authors declare no conflicts of interest regarding the publication of this paper.

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