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Cognitive Processes, ICT, and Education: A Critical Analysis

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ABSTRACT

Information and communication technologies (ICT) have brought about renewed spaces for the societies of today, full of possibility and transformation. Bordering on the infinite, these spaces have generated new activities and behaviors. This technological scenario is now commonplace, an everyday reality that has taken root in our lives with remarkable speed. Now would therefore be an appropriate time to open up a line of inquiry into how this is shaping educational practice and how it is affecting our cognitive structures. We have chosen to conduct a review of relevant literature that will enable us to adopt a critical analysis to our subject: education and, above all, the learner, seen from the perspective of neuroscience and social analysis. However, the principal aim of this paper is to lay bare the disparities between research findings and current educational practices that use ICT.

KEYWORDS

Educational reality; critical pedagogy; educational technology; cognitive load

Introduction

In this article we review some aspects of the use of ICT in schools. Nowadays, the digital has a profound transcendence in our daily lives, and ICTs have opened innumerable ways for innovation in education, making new environments and methodologies possible. We make a critical analysis from two fronts: on the one hand, in relation to the variety of interests that promote ICT use (e.g., didactic, political, economic) and, on the other hand, the results and indications that empirical studies and large evaluations have developed on their educational use. Understanding the multiple possibilities of ICT in education is not a case of taking an apocalyptic or integrated perspective as defined by H. Eco (1984) or of placing ourselves in one of the positions of the dichotomy between technoutopists and techno-sceptics defined by E. Morozov (2012). In this regard, we highlight the fact that "the use of technology in schools is transformed into an arena

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for politicians, school administrators and technologists" (Haugsbakk, 2011, p. 245), so we cannot ignore that educational technology has also become a field or struggle of different interests, with different stakeholders involved: national, supranational, public, and private (Selwyn, 2013).

On the other side, large reports such as the one carried out by the OECD (2016) show results that indicate that the technological promise in the field of education is still far from being achieved. In the same way, studies from cognitive psychology analyze how multimedia environments produce a cognitive load very different from traditional learning situations because of the large amount of information and stimuli they present. Floridi (2014), one of the most relevant authors of the philosophy of technology, emphasized that "ICTs are great in making information available; they are less successful in making it accessible, and even less so in making it usable" (p. 86). Therefore, a critical review of the uses that we are making of them in education is fundamental, understanding that the use of ICT does not directly translate into an optimization of teaching and learning processes and that the choice of these tools may be influenced by factors of a nature that go beyond merely educational.

We develop these different points, presenting first of all different empirical studies from cognitive psychology that show some of the evidence mentioned above, and then we present a critical analysis also alluding to the social, economic, and political spheres, and in particular, to educational policy.

ICT and brain plasticity: A cognitive analysis

We begin with an eye on neuroscience and cognitive psychology and address the concept of brain plasticity. This property of the brain determines its great possibilities for change in terms of its capacity to be reprogrammed and to adapt to different stimuli as a necessary condition for further and lifelong learning (OECD, 2007). We also appraise the classic confrontation between biological limits and the potential for adaptation to the environment which, in relation to plasticity, are categorized as experience-expectant, which is dependent on genetic factors, and experience-dependent, the result of interaction with complex environments (Gonçalves, 2012; OECD, 2007). The two variables define what are termed *critical* and *sensitive periods*: The critical periods are associated with the early years of life when neural connections develop on a mass scale; the sensitive periods, with education and the complex processes that connect structures and areas other than the brain (Ortiz, 2009). The traditional view of these two periods confined them to specific stages of development, but advances made by studies on brain plasticity and neuronal reprogramming have led to the conclusion that neither of the critical periods are as rigid as previously thought nor are the sensitive periods related only to stages of development (Ortiz, 2009). Such findings justify the great possibilities for learning throughout life and the importance of stimulation as one of the factors that influence the intensity with which our neural structures change and adapt. In 1949, D. O. Hebb, in *The Organization of Behavior*, claimed that the use/disuse of certain skills was an important trigger factor in brain connections. Doidge (2008) expanded on this claim, stating that if we cease to exercise our mental capacity (meaning a skill or specific activity) the brain does not simply forget, but the space dedicated to the old skills is given over to the new skills that have taken their place.

From the field of cognitive psychology, various studies have analyzed cognitive processes in complex learning situations in which technology and internet tools are also used. One of the most interesting contributions that justifies the thesis that we defend in this paper is that expounded in *cognitive load theory*, by J. Sweller (1988), which has been developed in recent decades through studies on instructional design and complex learning situations (Amadieu, Van Gog, Paas, Tricot, & Mariné, 2009; Chandler & Sweller, 1991; DeStefano & LeFevre, 2007; Merriënboer & Sweller, 2005; Paas, Renkl, & Sweller, 2003; Sweller, Ayres, & Kalyuga, 2011). This contribution to the field of education demonstrates how cognitive resources are used during learning and task solving, linking up elements such as working memory, prior knowledge, schema construction and acquisition, the design of learning situations, and the acquisition of new knowledge.

Another key aspect is the relationship of cognitive load with working memory, which Baddeley defined as "a system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning and reasoning" (Baddeley, 1999, p. 57), also showing this storage capacity to be limited. The design of learning situations should therefore avoid situations that could generate additional cognitive load and that entail more effort and a greater mental burden, thus negatively impacting performance by encouraging the creation and automation of schemata to free up cognitive resources (Merriënboer & Sweller, 2005). Sweller, Merriënboer, and Pass (1998) defined *total cognitive load* as the sum of three possible load types, which have also been studied by Kirschner (2002) and by Merriënboer and Sweller (2005): *intrinsic cognitive load*, *germane cognitive load*—though later revisions contend that it is probably inappropriate to use this term because it refers more to cognitive resources than to a type of cognitive load, as argued by Ayres and Paas (2012) and Choi, Merriënboer, and Paas (2014)—and *extraneous cognitive load*. The former is influenced by the nature of the task and the latter by the way it is presented.

Without going too deep, we can see how the cognitive load generated by a specific task has to do with the environment and the way it is presented and the characteristics of the learner and the interaction between these factors (causal factors). All this can be measured through *mental load* (related to the task and the environmental demands) and *mental effort* (capacity allocated to the task), and both, combined with causal factors, determine the subject's performance (Kirschner, 2002).

Armed with this knowledge, it is important that we design learning situations that generate a manageable cognitive load. It is therefore necessary to control the number of elements in interaction and how the new information is presented, since these are the key to improved processing when performing tasks and understanding new information, facilitating its storage in the form of permanent schemata in the long-term memory. Having recognized limitations in processing, the interaction between working memory and long-term memory becomes just as, if not more, relevant (Paas, Van Gog, & Sweller, 2010). We can influence the germane cognitive load by presenting structured learning situations, controlling the amount of information and its interactivity to avoid overexerting the working memory (Paas et al., 2003). If we show the information in a highly complex environment with multiple elements that interact through hypertext environments with an unclear hierarchy, the possibilities of filtering and working with that information will be the main constraint when faced with so much information. Weinberger stated that "it's not information overload. It's filter failure" (Weinberger, 2014, p.10).

On this basis, we will review different studies that analyze how activities in multimedia and network environments influence attention and cognitive load. Returning to the example of hypertext against regular text, multiple studies agree on the notion that the former requires more cognitive effort since attention is overloaded by the amount and variety of stimuli presented. Thus reading becomes more stressful and exhausting, it slows down, working memory is more saturated, and the resulting pressure directly affects the understanding of the text and performance. This was indeed pointed out by DeStefano and LeFevre: "The flexibility and interactivity proposed as advantages of hypertext result in a complex product that may increase cognitive load relative to processing of regular text" (DeStefano & LeFevre, 2007, p. 1617). Multimedia environments contain so many distracting elements that they force our attention to work much harder, especially in its selective facet. Hence authors like Small (2009) have argued that ICT leads us into a state of continuous partial attention that hinders our ability to focus on anything concrete due to overstimulation and that this can lead to stress or techno-brain burnout. Despite this, it appears that it also contributes to the development of the ability to multitask, although there are differing opinions on the efficiency of this multi-layered process because performance levels are lower as information is accessed more superficially (DeStefano & LeFevre, 2007; Small, 2009). Although the unification of categories and methods makes for diverse findings in research on this subject, there is general agreement that it may all have a negative impact on skills related to cognitive control, academic performance, and the socioemotional sphere (Schuur, Baumgartner, Sumter, & Valkenburg, 2015).

The new ways in which information is presented, together with the possibilities offered by audiovisual, graphic, and similar formats, have led to information being displayed in a more transient and less reiterative way. Consequently, the process of retaining information requires more effort and further saturates working memory in comparison with other formats (Wong, Leahy, Marcus, & Sweller, 2012). Studies on this subject also refer to the fact that pleasant and appealing presentations often require greater cognitive resources; this means that they are not always the best option for understanding and learning since they provide a greater amount of ancillary information and elements that can distract from the essential ideas (Schmeck, Opfermann, Van Gog, Paas, & Leutner, 2015).

Other more specific studies suggest that the hypertext structure increases cognitive demand since, apart from the processes associated with reading, there is a significant additional cognitive load relating to processes of decision-making and visual processing when compared to regular text (Shapiro & Niederhauser, 2004). Other studies have attempted to demonstrate the importance of the structure of the text, or even the number of nodes or links, on performance and the understanding of content in hypertext. Lee and Tedder (2003) noted through their research that hypertext interrupts continuous processing because of the jumps required to read it, making it difficult to understand the text as a whole and to extract the main ideas or to process it deeply. Balcytiene (1999) also analyzed the different reading patterns in relation to hypertext, noting that this format is more accessible for self-regulated readers who are able to read in an exploratory way than for readers who prefer a linear and systematic structure since they encounter more difficulties in creating reading itineraries and in considering the relevant links.

Calisir and Gurel (2003) contributed new ideas when they added that the greater the number of nodes or links the greater the increase in cognitive load and the use of working memory; reading and in-depth processing will be more complex for those who do not have as highly developed an exploratory capacity. Burin, Kahan, Irrazabal, and Saux (2014) classified hypertexts indicating that linear and hierarchical structures promote understanding and performance in learning tasks, compared to more highly branched hypertext environments with a more diffuse hierarchy and structure. Amadieu, Van Gog, et al. (2009) concluded that flexibility in exploring increases cognitive demand and that the dependent and not very highly self-regulated student may suffer from problems of disorientation since he or she is not able to trace paths through the information; the difficulties in creating mental representations thus become more pronounced. Amadieu, Tricot, and Mariné (2009) developed these conclusions a step further by analyzing prior knowledge and noting that the structure of the text does not significantly affect students with high knowledge levels, but that a hierarchical structure does significantly help those with low acquired knowledge or with learning difficulties.

All this evidence indicates that, despite the great advantages of ICT for presenting information and making it interactive, it can generate specific barriers and alterations in the neuronal structure and cognitive processing in learning situations and task solving. Through a synthesis of the significant studies that we have outlined, we may reflect, with deeper knowledge of the facts, on what ICT tools mean for our classrooms. Indeed, "their impact on student performance is mixed, at best. In fact, PISA results show no appreciable improvements in student achievement" (OECD, 2015, p.15). It is also worth examining how its incursion into curricula through various education policies is performing: We can indeed find schools that are blazing a trail in applying ICT-related methods, but they are based on entirely traditional educational schemes, pedagogical ideologies, and evaluation approaches. In this regard, "the use of technology in schools is transformed into an arena for politicians, school administrators and technologists" (Haugsbakk, 2011, p. 45). It is also necessary to undertake an analysis to ascertain what interests and values this technological momentum serves (McChesney, 2013; Selwyn, 2015). In short, as claimed by Rueda and Ferraz in their respective work, there is an urgent need for pedagogical criticism and, of course, critical pedagogy (Ferraz, 2012; Rueda, 2001).

ICT and the interests served by its application to education

Having demonstrated the enormous adaptability, re-programmability, and flexibility of our brain when coping with new challenges and unexpected situations, let us now pause to examine new technologies and the interests served by their incursion into education. In principle, none of these new technologies has been created ex professo for use in education—not even the internet or email, those all-powerful and boundless information channels, the precursors of which were military projects such as Arpanet.

All of these ICT tools have evolved at breakneck speed, in only two decades, since what Carr (2014) called the "dotcom bubble" began to inflate to alarming proportions. Large multinational companies have sought out new markets and come up with products to excite consumers, and no sector is as broad, dynamic, and responsive to innovation as education throughout the world and across its many stages and levels. It is no coincidence that the Santillana Foundation and the Telefónica Foundation have recently signed an agreement to review technology-related educational processes in Spain and Latin America, integrating technology as something imperceptible and natural. As Weiser (1991) has stated, "the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (in Paiva, Morais, Costa, & Pinheiro, 2016, p. 229).

Optimal effectiveness without risks and cost reduction appears to be the formula adopted by large corporations in educational settings. As argued by technology guru and founder of the MIT Media Lab and *Wired* magazine, Nicholas Negroponte, in just 30 years from now we will be able to learn whatever we want simply by popping a pill: "You're going to swallow a pill and know Shakespeare. And the way to do it is through the bloodstream. So once it's in your bloodstream, it basically goes through it and gets into the brain, and when it knows that it's in the brain in the different pieces, it deposits it in the right places" (Ayuso, 2014; Negroponte, 1995). Negroponte appears to have solved at one fell swoop three problems of enormous magnitude in which pedagogy has historically been found wanting: the economic and social differences in access to knowledge, the selection of appropriate content to be learned and assimilated by future citizens, and the methods—widely debated for over two thousand years—for truly engaging with content and fixing it in the memory. Of course, this begs the question: Who will create these quasi-miraculous pills, for what purpose, and for whom? We should bear in mind the fact that these pills or robots will play their part in a growing industry that moves more than 19 billion euros a year. The European Union (EU) announced an investment of 2.8 billion euros in a sector in which Europe has a 32% market share. The scale of this market is made quite clear when we consider that Google has purchased eight robotics companies in recent years (Altares, 2014).

But from the point of view of governments, at least for some, due attention is also being paid to this market: The subject of robotics, under the title "technology, programming, and robotics," has been introduced regionally as an optional subject in all schools of the Autonomous Community of Madrid in the first three years of compulsory secondary education, starting from the 2015-16 academic year. The fact that the Madrid regional government has made a commitment to this field illustrates its potential to promote practical activity and to maintain a certain pro-business educational line, which impedes the introduction of other disciplines that are more given to thought, reflection, and debate, a criticism that has been leveled at the new curricula in almost all countries (Schuessler, 2013).

The commitment of multinational companies and governments to promote the internet and robotics has been repeated in the case of mobile phones—so much so that the vast majority of bureaucratic procedures both in and out of schools, and in most government offices and in all kinds of institutions, only admits users of this technology. In the case of Spain "the proportion of children (10 to 15 years) using information technologies is generally very high" (Instituto Nacional de Estadística [INE], 2016, p. 3). The same source reveals that at age 10 the percentage of students who have a mobile phone is 25.4%, although that number skyrockets for 15-year-olds, at almost 94% (93.9%). Spain leads the way in the EU in terms of smartphone numbers, with 23 million units. Also, Spain leads the world ranking of unique mobile users with 88% penetration, compared to 82% in the United States and the global average of 66% (DITRENDIA, 2017). Only 24% of Spaniards prefer to communicate in person (Aguayo, 2015). If we consider that teenagers send an average 3,000 text messages a month, this gives us an idea of their enormous communicative and empathetic needs (Turkle, 2011, 2015). According to a study made by Common Sense Media (2015) on U.S. teenagers (13-18 years), they spend almost nine hours a day on media devices (not including time spent for school or homework). What had been interpreted until now as a broadening of social communication has become mere connectivity and personal isolation. Worse even is the perhaps unsurprising profusion of new terms to define the dependence that mobile phones as a technological device generate: nomophobia (fear of being without it), techno-stress (tiredness caused by permanent use and by other electronic devices), phubbing (snubbing someone in favor of a mobile phone), sociophobia (fear of the society that surrounds you and taking refuge in the virtual world), infoxication (too much information without selecting or applying rational criteria), etc. And as these pathologies are classified, detoxification centers are beginning to proliferate in high-tech countries like the United States, South Korea, China, Japan, Australia, and Spain. There are even dedicated sidewalks in China for mobile addicts so they do not have to step aside or bump into anything or anyone. Quite the opposite of what is happening in certain American states, like Hawaii, Arkansas, New York, and Illinois, where there is a ban on using mobile phones on sidewalks, crosswalks, and road edges or shoulders because of the danger that they pose.

In a small-scale study that we conducted with 79 first-year students of the Early Childhood Education degree at the University of La Laguna (group 1), participants were asked to switch off their mobile phones for one weekend (starting at midnight on Friday), having first notified their relatives and acquaintances of their intentions. The most dependent of the students

(63%) only endured being disconnected while they slept (6-9 hours); others (27%) switched them on by noon on Saturday (12-14 hours disconnected), and only 10% managed to last for between 20 and 30 hours without their mobile phone. Of this sample, none lasted the scheduled 48 hours of an entire weekend without connection; most acknowledged orally that they were in thrall to their mobile phone. We should not therefore be surprised that educators and psychologists warn of the damage caused by these devices at an early age and the importance of going on "digital diets" when a moderate and rational usage threshold has been exceeded.

As mentioned above, this is all taking place in developed countries since in the 39 countries classified as "least dynamic" by the ITU (International Telecommunication Union, a specialized agency of the UN), with a combined total of 2.4 billion people, these health problems do not exist. However, it has been pointed out that these countries cannot "enjoy" the "great improvements in areas such as education, health, or employment with greater access to these technologies" (EFE, 2013). As we see, even the highest level international bodies insist on the idea of the benefits that are derived from new technologies in educational settings; and it is not the case that ICTs per se (i.e., as mere tools) have perverse effects. It is more the case that—as claimed by Jaron Lanier, a computer expert who coined the phrase "virtual reality"—"we should understand that we have entered a game governed by zero-sum mindsets, in which we try to make the world fall into the trap of ignoring reality" (Lanier, 2014, p. 349). More explicit than that, if possible, were the remarks of Morozov, who said that "often ["cyberutopianists and internet-centrists"], completely forget the political nature of technology" (2012, p. 21; also McChesney, 2013). The problem is not the existence of technology, the use that we make of it, or the level of sophistication that we allow it to have to make life more comfortable; rather, the problem lies in the ways of thinking about technology to the point where we have transformed it into part of ourselves, an extension of our being, unaware that it is a commercial tool of domination and control that "attracts our attention only to scatter it" (Carr, 2011, pp. 143–147).

Indeed, the real world is confusing, chaotic, and incomprehensible, and we try to halt its onward march by using machines that engulf us in a more pleasant and desirable virtual reality, to such a point that we lose the sense of active physical presence. It hardly seems necessary to mention the Oculus Rift VR headset, the major business venture of Facebook and its owner, Mark Zuckerberg, which creates a feeling of immersion and "how the real world and the virtual world merge" (Jiménez, 2016, np.) As we have seen in the first part of this article, the automation that new technologies of all kinds are exposing us to restructuring and reconfiguring the activity that we do, the environment in which we do it, and most pointedly and disconcertingly, those who are making use of the technology.

Education and its permanent uncertainty

From the 1990s, publications of considerable interest began to emerge, highlighting the advances that new technologies could bring to education. The beneficial influence of computer systems and software has been felt in all forms and stages of education, from formal, through nonformal and informal, and including higher education. A cursory search for documents containing the search terms *educación* and *nuevas tecnologías* on Dialnet (the Spanish academic search engine) from 1994 (although on a mass scale from 1997 onward) to the end of 2016 returned 276 results pages—a total of 5,505 documents. In none of the documents consulted did we read a critical assessment of the purported aims of such widespread diffusion of technology, the soaring stock market value of the companies that had climbed aboard the bandwagon of social and educational progress, or how the hardware and software for these ICT systems are selected at will from other fields of knowledge to be adapted (sometimes forcibly) to teaching. Even less was written on how these technologies distracted the attention of students, distanced them from reality and fractured knowledge, and turned them into completely dependent beings. The focus was on ICTs as simple work tools, as instruments to facilitate the transmission of knowledge—or rather, information—and as mechanisms that are devoid of any negative or minimally questionable connotations regarding their functionality or operability. New technologies, and the megabusiness that surrounds them, have firmly established themselves in schools, colleges, and universities, convincing them of their potential and becoming a permanent feature.

But despite the use of new technologies, the contradictions in educational systems are on the up. Virtual classrooms, interactive whiteboards, mobile applications, laptops, interactive programs, online searches from any terminal, digitization of much of the content and materials, smart devices used for tracking purposes, digital environments of all kinds, exchanges through chat rooms, text messaging, social networks, blogs, wikis—all of these formats—continue to coexist with traditional presentation modes, with archaic methods, with rote evaluations and test-based assessment that only value certain skills and require simple answers but do not evaluate the process of acquiring knowledge and the critical experience-based knowledge acquired through synthesis of the whole. In other words, such widespread acceptance of ICT has not been accompanied by a holistic and innovative vision of the change that such resources entail for a 21st-century classroom. Or, to frame it in the words of a teacher, De Pablos (2015, p. 16): "The quality of education outcomes is not so much to do with the presence or absence of technology as with applied pedagogical models and the conditions under which they are applied in the classroom."

But perhaps the solution to the education/technology equation is not so readily apparent and even less manageable; it may not even, strictly speaking, be pedagogical. With the digitization of the classroom and with the new education laws enacted in these times of globalization and neoliberalism—what has been called "new capitalism"—educational reality has changed considerably. Selwyn stated that "[m]any of the 'new' forms of digital education being driven by commercial interests are based around decidedly different agendas and ideologies than we are used to encountering in public education" (Selwyn, 2016, p. 131). Let us take an example known worldwide: In 2002, the George W. Bush administration passed a literacy law called the *No Child Left Behind Act*. With all the technologies at their fingertips, American teachers were forced, thereafter, to choose between teaching general knowledge or teaching to pass exams, which was what essentially was being asked of them.

What began as a kind of laboratory test in 2002 has since spread all over the world as education laws have been amended to adapt them to the demands of the markets. Perhaps here we have a first clue as to the origins of the technological avalanche: its adaptability to new policy needs and to cuts in public spending and its enormous business potential. If technology use and information overload are distracting, if multitasking reduces the possibility of learning complex skills, if there are certain cognitive loads that cannot be exceeded without clear risks for the health of students, if virtual reality distorts and manipulates authentic social reality, if empathy decreases as technology advances, if new technologies motivate enjoyment but not effective learning, if computers dehumanize the process of acquiring knowledge, etc., as evidenced by the most recent research, then why spend so much effort and energy in its defense? Have we truly considered—as did educators of the past—what the purpose (and means) of education should be in this new learning context? Have we paused to reflect on the type of student and citizen that we want to educate in times of such uncertainty, on the real, sustainable society that we want for our descendants? Or, are we shaping an education for tomorrow that is at the mercy of the latest algorithms, computer applications, and robotic pills? Who will be the new education specialists: teachers and pedagogues or computer programmers and tech gurus? In his report to the European Parliament in 2010, psychologist and neurophysiologist Aric Sigman warned of the harmful effects of screens on children and concluded his presentation with the following presage: "There is nothing to be lost by children watching less screen media but potentially a great deal to be lost by allowing children to continue to watch as much as they do … . we may ultimately be responsible for the greatest health scandal of our time" (in L'Ecuyer, 2015, p. 210).

In light of this, and assuming that, far from disappearing from our lives, technology will continue to increase exponentially to satisfy the many interests vested in this market of unprecedented growth (and unscrupulous when it comes to health concerns; Briones, 2016), it seems clear that we must change the logical assumptions on which we have based current educational expectations. This has already been done by certain members of the tech elite. In Silicon Valley, the children of the famed computer technicians of Google, Apple, Yahoo, and Hewlett Packard go to the Waldorf School of Peninsula where computer science is only taught from the age of 13, pencil and paper are the tools used for writing, traditions are fostered, the bond of solidarity is nurtured between pupils, and there is a constant search for a culture of "disconnection" or "digital retreat" (de-teching). Pierre Laurent, the father of one of these children, is quite clear about their aims: "Screens disrupt learning. They diminish physical and emotional experiences" (Abundancia, 2016; Richtel, 2011, p. A1). Moreover, Steve Jobs, co-founder and CEO of Apple, was another who did not encourage the use of technology among his children. According to information that has recently come to light, he did not allow them to use an iPad and limited the use of other technologies because he did not deem them necessary during their formative years. There are other similar accounts. For example, one of the founders of Blogger and Twitter has stated that his children use traditional books instead of iPads and that they have been forbidden access to the internet until they reach the age of 16 (L'Ecuyer, 2015); this is true for a host of leading experts in information and communications technology, who consider instruction received by children and young people through any kind of screen display to be ineffective.

At this juncture we are able to better understand the OECD report (2015) entitled *Students, Computers and Learning: Making the Connection* in terms of its questioning of how new technologies are used to achieve real and effective learning and to reduce school drop-out rates. Francesco Avvisati, the author of this report, stated that "[w]hile there is too little credible evidence on this issue, positive findings are limited to certain contexts and certain uses of ICT" (OECD 2015, p. 190). In fact, class time or teacher/student relationships have a greater influence on results than the technologies used. Avvisati continued: "They [countries] can more clearly identify the goals they want to achieve by introducing technology in education, and strive to measure progress towards these goals" (2015, p. 191). In his foreword to the report, Schleicher claimed that "we may overestimate the digital skills of both teachers and students, because of naïve policy design and implementation strategies, because of a poor understanding of pedagogy, or because of the generally poor quality of educational software and courseware" (OECD, 2015, p. 4). Therefore, we can say that technology, sensu stricto, does not seem to have an effect on academic achievement beyond being a simple and additional aesthetic, recreational, and educational complement. In light of new research, we shall have to keep asking ourselves whether it is worth defending from the demanding and vigilant vantage point of pedagogical responsibility; as Edith Litwin stated, "It is not the technology that allows us to bring about change, but our decision to imagine with and through it" (Falco & Kuz, 2016, p. 44).

Conclusions

At this technological pinnacle in all spheres of life, particularly in education, we have tried to draw on research and on reports to demonstrate that the advances and results that have been brandished with such keen interest and exuberance are not all that they seem. We have also seen how technology did not arise to tackle pedagogical or educational problems but to meet other political requirements and to capitalize on a booming education market that had no great demands or expectations. In fact, if we return to the OECD report (2015) we can categorically declare in the strongest terms that "the reality in our schools lags considerably behind the promise of technology" and that technological promise also announced that it would reduce the gap between different students; however, the report concluded that "technology is of little help in bridging the skills divide between advantaged and disadvantaged students" (2015, p. 3), as was foreseen. Following this line of argument, the introduction into educational practice of any technology should be conceived and justified from the perspective of pedagogical knowledge, which enables us to reflect on the whys and wherefores of its use and whether it really optimizes the teaching and learning processes. We have gone from graphite (pencils) to graphene (mobile phones and other electronic terminals) without giving thought to the positive and negative changes that this mental and cerebral process generates. We are convinced that the teacher/student relationship is indispensable for complex cognitive processes and rigorous analysis of concepts and interpretive approaches. As Emilio Lledó, a teacher who received the 2015 Princess of Asturias Award for Communication and Humanities, stated:

- The mission of the teacher transcends the subject that they teach.
- In the real space of the classroom, in the words they utter, they encourage a beautiful phenomenon of love. It has been written that teachers have to love what they teach but, above all, those whom they teach (Lledó, 2015, p.14).

Therefore, we can conclude that no technology, however cutting-edge it may be, can replace the teacher in making students understand, feel, touch, transmit, and manage the immediate reality that affects them, with his/her exceptional experiences and his/her particular economic and social background.

Therefore, one might ask whether democratization is being given priority in the processes of individual autonomy in politics and whether production relations are imposing a model of information control that is far removed from the interests of citizens. If the school, as a privileged institution in the creation and transmission of learning, is activating the necessary mechanisms to create awareness about the transformations that result from use and abuse of ICT (Haugsbakk, 2011; Selwyn, 2013), the necessity of creating both medium and long-term political and research agendas—capable of accompanying these techno-educational transformations—becomes evident and should not culminate in the delivery of devices but begin at that point. All this offers us indications of the new lines of research to be undertaken in future studies.

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