DIGITAL TECHNOLOGY: CRITICAL AND CAUTIONARY OBSERVATIONS

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ABSTRACT

This article critically discusses the influence of digital technologies on the human mind. It traces the complex relationship humans have with technology, both in historical and modern terms. With the invention of the digital code particularly, humans have created a technology that operates at the level of the mind, rather than at the level of the body, with enormous potential to fundamentally change our cognitive faculties. The article further investigates the health implications of the combined use of digital media and electronic devices, as well as their impact on learning and academic achievement. It attempts to dispel the myth of differences between so-called "digital natives" and "digital immigrants" and concludes by advocating for a more cautious and knowledgeable approach to the incorporation of digital technologies in our everyday lives and educational processes.

Keywords: digital technology, human cognition, digital natives, attention economy, health effects, learning and academic success

1. INTRODUCTION

The roots of technology reach deep into history, tracing back to the era when *Homo habilis* (Latin for "handy man"), first used stones and bones as tools roughly 2.5 million years ago(Susman, 1994). Our ancestors utilized such objects for limited set of actions, like smashing, boring holes, slicing, as rudimentary weapons, etc. These tools, in turn, shaped the brain and bodies ofearly humans, and since the very beginning, the relationship between humans and technology has been reciprocal: humans create technologies, and technologies modify humans. For instance, it is evident that the use of those ancient tools played a critical role in the evolution of our hands, particularly leading to the development of the opposable thumb—a finger uniquely positioned to allow intricate handling and manipulation of objects (Karakostis et al., 2021).

Nevertheless, the rudimentary tools crafted by our early ancestors pale in comparison to the pervasive, mass-produced, multifunctional and complex digital tools that define our modern era, such as smartphones and computers. In contemporary society, these devices have become indispensable extensions of our daily lives. Underlying our core human activities—communication, entertainment, and commerce—they have risen to become the technological backbone of modern civilization. Our knowledge, economies, and very identities are now highly dependent on thecomputer technology and the Internet, encoded in the invisible binary language of ones and zeros.For the first time in our history, we have invented the digital code that gave rise to the new digital environment, intrinsically different from the physical, natural, and social environments in which humanity has evolved(Kirjakovski, 2023).Today's technology is far reaching and deeply transformative, with even bigger potential to reshape our mind, just like the rudimentary tools of our ancestors reshaped their

bodies. Hence, this paper analyzes some of the properties of the new digital technologies and their effects,taking a critical, cautionary, and carefully plannedapproach towards their use in the educational process.

2. DIGITAL TECHNOLOGY ANDHUMAN ADAPTATION

2.1Traditional versus digital media

Before humanity developed digital code and computational hardware, in Europe, another significant technological shift occurred in the 15th century with the advent of the printing press by the pioneering Johannes Gutenberg. The press set a stage for mass dissemination of information and ideas. Before the press, books were written, copied, and decorated by hand, generally kept in libraries in monasteries, out of reach of the general masses. That modest printing press had an incredible decentralizing effect, led to the demonopolization of knowledge and mass education, took the power out of the hands of a small elitist group of politico-religious potentates, and gave it to the broad masses. The shift of informational power produced vast societal changes throughout the world but was also the reason for many bloody societal revolutions in the centuries to come.

And yet, the mass proliferation in the Gutenberg sense is negligible compared to the proliferation of digital media today. The latter differs fundamentally from the "traditional media," like radio, newspapers, magazines, books, billboards, television — in essence, all forms of analog media that predated the advent of computers and the Internet. The first major difference between digital and traditional media lies in the structure of their "DNA": unlike traditional media, information in digital media flows in the form of zeros and ones, which modern machines are capable of interpreting and converting into both – analog and digital signals. Thus, audio, video, graphics, text, software, and, more recently, 3D printed figures, all can be recreated and embodied as physical stimuli and objects by following the long binary recipe. The binary skeleton of modern digital devices makes them interrelated not because of their physical appearance and morphology, but because of their shared digital DNA. This is similar to how humans are connected to other species: although our physical forms vary, our common biological DNA links us to the rest of the animal kingdom.An iPhone is similar and related to a Samsung Galaxy smartphone, not because of their shape and design, but because of the algorithms that fundamentally operate on the same binary code.In contrast to the analog signals and operations in traditional media, digital code is translatable and mutable. In principle, digital technology could initiate parallel digital evolution where certain codes and algorithms become dominant under the humas' or machines'artificial and natural selection. The recent introduction of Generative AI systems and chatbots based on large language models like ChatGPT(OpenAI, 2023) to the general population is the best indicatorfor a possible future with self-selecting, self-adapting, and self-evolving machines that coexist in parallel with humans.

Furthermore, content consumption differs significantly in the context of digital media. In traditional media, people were mostly passive consumers with limited control over content. This changed with the introduction of social media and services like YouTube, where users have become both consumers and content creators. In other words, digital media have transformed us from passive individuals into individual mediums. Besides, communication previously most often occurred in a one-way manner (from media to user) and did not offer many options for interaction with the viewer, listener, or reader. Now, digital media are multi-directional, and their main *modus operandi* is multitasking and interaction with the user. Such functional designs have important implications for the use of current and future digital devices with modern technology companies frantically searching for ultimate forms of interactivity, even in forms of virtual realities(for e.g., "Metaverse"; Mystakidis, 2022).However, one unforeseen consequence of the hyperinteractive design is the relatively high

degree of psychological dependence. The addictive effect of digital media seems ubiquitous and global, involving many nations and cultures, especially those cultures classified as collectivist, although the percentage is also significant in individualistic cultures(Cheng et al., 2021). Some meta-analyses estimate up to one quarter of the global population suffering from smartphone, and to varying degrees other forms of digital addiction(Meng et al., 2022).

Reports on digital technology reveal large consumption of digital devices and services. For example, 68% of the world's population are mobile phone users, 64.4% access the Internet, and 59.4% actively engage on social media platforms(DataReportal, 2023).Despite the large numbers, it is very important to maintain a critical approach in understanding the phenomenon, i.e., we must not accept digital media *a priori* as "the new normal" without understanding deeply what emerges from their use and omnipresence over time. Given that digital technology is a relatively recent development, its true impact is yet to be known. In other words, the long-term effects of such technologies are still unknown. It is naive to think that humanity will adapt seamlessly just by incorporating digital devices into our lives, and we should not disclaim their detrimental potential. We should not presume "by default" only their technological utility, especially when they are implemented in classrooms and used by new generations of children and youth. Probably in the long run, yes, we will adapt, but the real question is at what cost. If our goal is a more intelligent humanity in a safer and more prosperous world, one must not jump to unverified conclusions, and a more careful approach to digitalization is required to minimize the damages and maximize the benefits. The adaptation to the new forms of digital media and technologies cannot be modeled onto the old forms of mass media, since the digitalized world is vastly more personalized, dynamic, hyperconnected, hypersocialized, ubiquitous, automated, and multifunctional.(Kirjakovski, 2023).

2.2The pitfalls of digital content personalization

Despite their unprecedented global reach, modern digital technologies paradoxically are tailored to each of us individually. For instance, the Twitter feed displays and recommends content unique and personalized just for the user. The recommendations are generally chosen through machine analysis of the user's habits, interests, and usage patterns. Similarly, Netflix offers different movies to you andto your lover, parents, siblings, or friends. Even Google searches are tailored according to the user's location and past search history. In alarming departure from traditional media – digital media present personalized content to each of us, essentially offering different versions of "reality." The phenomenon could be named the *paradox of globalization*, where despite being more connected than ever, and despite the ability to communicate unlimitedly with anyone at any location on the planet, personalized technologies make us perceptively distant, fragmented, isolated, and living in "different" realities.

Thus, it is not very hard to imagine a world of diminishing mutual tolerance, increased polarization, and conflict, in which we mistakenly believe that others see what we see and any difference in opinions is understood to be due to others being "uninformed" or "stupid." Such a situation is best summarized by the famous psychologist Lee Ross, who talks about "naïve realism" – a state in which we falsely believe we are the objective ones, that we see things more credibly than others who are either "irrational" or "more biased" than us(Ross & Ward, 1996). As digital media become increasingly complex to use, a potential widening generational gap emerges, where older individuals may struggle more in understanding how to use them, further increasing intergenerational polarization in societies. How can we be tolerant and understanding of each other if we don't even accept a basic minimum definition of what reality is?

The personalized content has another dark side. In the era of traditional media, user data about content consumption were typically collected through classic research methods (surveys, viewer/listener/reader counts, etc.). The classical methods were relatively superficial and limited, largely anonymized and private, and predicting future user behaviors was extremely difficult. In the era of digital media, a vast amount of user data is collected and analyzed by powerful and thorough machine algorithms, via automated processes that can create profiles of behaviors and interests virtually from unlimited data generated by the user themselves. Ironically, machines know more about us than we know about ourselves. We lose privacy, intimacy, and uniqueness. And all of this is hyper-normalized – the loss of privacy as a value became "normal;" our personal and private lives are publicly available and documented through photos, videos, or statuses on social networks, often willingly posted by ourselves. The combination of super-powerful computing machines and algorithms that collect a vast amount of data about us and human ignorance can easily lead to societies with "rosy" totalitarianism and "control for our own good." The conditions described above also have very serious implications for our security, especially when we engage in Internet activities, during which often we become targets of hacker attacks and social engineering, eavesdropping, threats, and extortion.

As we enter a new digital era, we find ourselves with a new digital Gutenberg press in our hands, one with far greater potential to impact the world. Modern digital technologies currently serve us well, enabling immense productivity, growth, and development. However, at the same time, we must not uncritically apply them and forget about the potential dangers if we take them for granted, if we allow machines to think for us, to find us friends and lovers, to entertain us by their choice, and to define our realities and ethics. We must not allow ourselves to think less and less. If technology is capable of morphologically shaping our hands, of stimulating the development of the opposing thumb, it surely can influence and shape our minds even more. Precisely because of this, we must not remain passive and ignorant toward digital technologies and must understand more deeply and carefully our symbiosis with them.

3. THE HALOS AND MYTHS OF DIGITAL TECHNOLOGIES

3.1 The digital halo effect

A small footnote from the book *Profiles of the Future* by the legendary science fiction writer, futurist, and screenwriter Sir Arthur C. Clarke, became known as "the third Clarke's law" and states: "Any sufficiently advanced technology is indistinguishable from magic"(Clarke, 1973, p. 21).The same goes for digital technology. It seems magical, advanced, mystical, powerful, and sophisticated. But is it so? Should we really look at digitalization as magic that will solve all the problems in education? Does the digitalization of the education process truly create positive and advanced effects in the psychosocial and cognitive development of children and their education? These questions are empirical and scientific, not matters of fantasy, politics, or ideology.Nevertheless, digital technology has many advantages, such as the speed of information processing, automation, communication, connectivity, networking, and precision. With the help of computers, humans have landed on the moon and soon, hopefully, will be landing on the planet Mars. But is that a reason to blindly accept this technology as magic and fervently promote and adopt it? No. There is nothing magical about digital technology, and those who consciously or unconsciously believe it is the ultimate solution to all our current and future problems are falling for a version of the cognitive bias called the *halo effect*, or the mistaken belief that if something is good in one domain, then it must be good in everything else(Nisbett & Wilson, 1977; Thorndike, 1920). The point is: if digital technology is good in a certain area, it doesn't mean it is good in every area of human endeavors.

3.2 The myth of "digital natives"

Younger generations are often stereotypically viewed as some kind of new digital beings described by the term "digital natives", a speculative coinage by Marc Prensky (Prensky, 2001). This expression implies that young people who were immersed into the digital technology since birth, are entirely different from those generations who did not grow up with digital technology but adopted it later in life, whom Prensky calls "digital immigrants". The problem is that this thesis about digital natives is often uncritically accepted as a truism with little evidence for differences between the cognitive architecture and natives and immigrants(Bennett et al., 2008). According to Prensky's definition, digital natives (born after 1980) are immersed in technology, "surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all the other toys and tools of the digital age"(Prensky, 2001, p. 2). Further, Prensky believes that they are "used to receiving information really fast … like to parallel process and multi-task ... prefer games to 'serious' work" (Prensky, 2001, pp. 3–4).

Referring to the needs of digital natives, Prensky called for radical changes in the educational process. According to him, students have radically changed, and today's students are no longer the people for whom our educational system was originally designed. At first glance, his call seems logical, but again, we must think critically and ask: are these ideas and calls scientifically justified? Are digital natives really a separate category of people with special cognitive abilities and psychology for which we need to change the entire education system from the ground up? Critical reviews of Prensky's theses classify them as "moral panic in academia," finding no strong scientific support for his claims(Bennett et al., 2008, p. 776). Moreover, Bennett et al. (2008)call for not making policies based on such a variable, diverse, and unclearly conceptualized population as "digital natives." Instead, the authors call for decisions in education to be based on evidence, facts, and research on relevant populations and proven effective methodologies. Additional support for the conclusions ofBennett et al. (2008)comes from Helsper and Eynon (2010)who provide evidence that adult populations not born into the digital technology can also become "natives" through acquiring skills and experience in interaction with such technologies. Finally, a study of a large sample of the student population from different faculties did not find evidence for the stereotypical "digital-native" and characterized their participants, at least in their sample, as students who prefer "conventional, passive and linear forms of learning and teaching"(Margaryan et al., 2011, p. 439).

In short, the claims and generalizations that new generations of students are digital natives with special digital skills, advanced cognitive capacities, and special educational needs – are not scientifically supported, and decisions for reforms in education should not be based on this stereotype.

4. DIGITAL TECHNOLOGY IN RELATION TO ATTENTION, LEARNING, AND HEALTH

4.1 Attention in a world full of information

If the 20th century was the century of information, the 21st century is the century of attention. We are constantly inundated with information through various digital channels – YouTube, Facebook, Twitter, Instagram, Netflix, Spotify, Apple TV, the Internet, advertisements, video games, computers, e-documents, podcasts, virtual and augmented reality – each one of them fighting for our attention. According to the American Psychological Association (APA), attention is defined as "a state in which cognitive resources are focused on certain aspects of the environment"("Attention," 2018). In one of his works, the renowned cognitive psychologist and economist, Nobel laureate Herbert A. Simon, described attention as a "bottleneck," and he is also credited with the phrase "economy of attention," a concept according to which attention is a

scarce and limited resource in a world full of information that modern technological companies compete to capture(Simon, 1971).Attention is a fundamental cognitive mechanism for focusing, selecting, and organizing information that, in the digital age, faces serious challenges by being predominantly targeted by digital services. For that reason, it must be used economically. The implications are even more important in children whose attention goes through developmental phases following the biological development of their brains. With age, children increasingly acquire the ability to control and focus their attention, but in the digital era, children's minds increasingly resemble a *grasshoppermind*, and their attention "jumps" indiscriminately from one place to another, captured by various digital stimuli(Papert, 1994).

4.2 Digital media, multitasking, and learning

Unlike television, radio, and other traditional technologies, electronic devices such as computers, tablets, and phones are multifunctional. They are designed for multitasking with constant connectivity to the internet. Multitasking can be defined as the simultaneous processing of multiple streams of information by focused attention. In the media context, it can also be understood as the use of two or more digital media concurrently on the same or different devices (e.g., listening to music while simultaneously reading an electronic document on a computer screen).The third way to understand multitasking is consuming media while performing non-media activities simultaneously, such as writing messages on one's phone during dinner. The nonprofit organization that researches national health and health policies in the USA, Kaiser Family Foundation, estimates in its 2010 report that 8-18 year olds spend an average of 7 hours and 38 minutes on various entertainment media through their devices, and one-third of that time involves multitasking(Rideout et al., 2010). Similar estimates are given by a more recent 2019 study by the nonprofit organization for digital technologies, Common Sense (*Media Use by Tweens and Teens 2019: Infographic*, 2019).

Since our cognitive capacities and resources are limited (especially our attention), the problem occurs when we are dealing with tasks and activities at the same time. Various studies demonstrate that our efficiency decreases, our performance suffers, and we are increasingly distracted when we multitask(Cain & Mitroff, 2011; Ophir et al., 2009; Uncapher et al., 2017). Multitasking has serious implications for the process of learning, which is especially disrupted in the context of mobile phone use(Chen & Yan, 2016). Furthermore, in a scientific reviewin 2015, a group of researchers from the University of Amsterdam reviewed 56 papers on the topic and came to the conclusion that multitasking during lessons or studying is associated with lower academic performance, negative attitudes, and behaviors toward learning(van der Schuur et al., 2015). Additionally, multitasking appears to affect cognitive control and the ability to maintain attention, and those who multitask on their devices have difficulty focusing and dedicating themselves to a single activity. Young people who reported a high degree of multitasking in the reviewed studies also exhibited lower emotional well-being and sleep problems later. Based on these correlations, the multitasking built into digital technology should be taken seriously due to its power to disrupt efficient attentional processes, and many more studies are needed to explore and guard against the negative consequences for knowledge and academic success.

4.3Smartphones, tablets, and laptop computers in the classroom

The French government enacted a law that came into force in September 2018, which banned the use of phones by students while at school in France. Asked why students up to their 15th year of age (up to the ninth grade) will not be able to use these devices at school, French Minister of Education Jean-Michel Blanquer responded that removing phones from the classroom would lead to better focus and concentration among students, improved socialization, and prevent children from wasting time on social media(Busby, 2018). This decision seems correct in the education context since longitudinal studies conducted in Ireland, which analyzed data from 8,500 9-year-olds who owned mobile phones, show that the use of these devices is

associated with a drastic reduction in their abilities to read texts and understand mathematics(Dempsey et al., 2019). The authors of the study conclude that owning such a device from an early age carries significant educational costs. Another study conducted at schools in four English cities that had voluntarily banned mobile phones shows an increase in academic success among students some time after the ban, and more interestingly, the improvement in success was greatest among students who had previously shown the poorest results(Beland & Murphy, 2016).

Smartphones are not the only devices that can have negative consequences for learning and academic success due to attention being diverted away from educational material during class. Tablets are increasingly used in education, although there is relatively little long-term research on their effects. For now, it can be concluded that they are quite similar to smartphones in terms of physical design, connectivity, operability, and audiovisual capabilities, as well as processing power. What can be done on a phone can also be done on a tablet, and it is possible that all the negative effects on learning evident in smartphones could potentially apply to tablets as well. Qualitative research reports reveal that students and teachers who were part of a project using iPad tablets in U.S. schools express mixed feelings about their implementation in interviews, acknowledging that although they appreciate the concept and use them for productivity, tablets can be distracting in the classroom (Ditzler et al., 2016).Nevertheless, one of the rare published reviews on the topic generally finds more positive than negative effects oftablet usein education, but the conclusion is valid only when they are used as supporting devices in teaching, thereby calling for caution when generalizing (Haßler et al., 2016).The assumption that tablets will lead to an improvement in academic performance is arbitrary and needs to be thoroughly researched. For instance, in the USA, despite the growing use of tablets and other digital devices in education, the latest PISA reports show that success in the three parameters – reading, mathematics, and science – either decreased or remained without significant improvement or deterioration(OECD, 2023a, 2023b). Data from South Korea, which introduced digital textbooks into education from 2012, indicate performance levels in the latest PISA report not very different from the period of 2018, although their students still rank high above the world average. In Sweden, one of the most digitalized countries in the world, PISA results show deterioration after 2018. Despite the similar trendsamong the threeexamples, digitization processes, technological adoption, and effectiveness in the classroom should be considered culturally sensitive and could reflect differently in different cultures.

Finally, as for the use of other digital devices in teaching, such as computers, for example, some studies show that the use of laptops during lectures corresponds with poorer learning outcomes because these devices disrupt attention and take time away from the lecture dedicated(Fried, 2008). Additionally, most students admit they spend significant time using laptops for activities unrelated to learning. Even more concerning is that other studies note multitasking on a laptop not only disrupts learning for the user but also detracts from the attention of those nearby, disturbing their ability to follow the lecture as well(Sana et al., 2013).

4.4 Health and cumulative use of electronic devices

This paper discusses digital technology mostly in the context of education, but smartphones, tablets, laptops, and other electronic devices are also used extensively outside the classroom. For this reason, when evaluating the effects of such technologies, one must consider the combined use of digital media and electronic devices. Children and adults also spend time watching television, adding to the total screen time. Therefore, it becomes even more important to anticipate, recognize, and prevent the potential health consequences from the cumulative time spent in front of screens of various electronic devices. For example, a review published in the "Journal of Paediatrics and Child Health" concluded that watching television negatively affects locomotion, physical strength, dietary habits, and adiposity in children(Domingues-Montanari, 2017). Spending more time in front of TV screens or playing video games on a computer is associated with obesity in children, weight

gain, sleep problems, and a reduction in its quality and duration. Additionally, children's cognitive and socio-emotional development is affected, which later impacts their mental health in adolescence. The consequences for mental health from the use of "new media" (electronic devices, social networks, etc.) are discussed inTwenge et al. (2018), who collected data from a large number of youths aged 13 to 18 in the USA (506,820). The authors concluded that those who spend more time in front of screens experience more mental problems compared to those who spend more time in face-to-face social interactions, sports/exercise, and reading printed media. The study also detected a worrisome increase in depressive symptoms among teenagers as well as an increase in the suicide rate, particularly among the female part of the population. In a more recent article,Twenge et al. (2020)again warn against the error of underestimating the negative effects of digital media by providing evidence of a positive correlation between daily social media use and symptoms of depression, which is especially prevalent among girls.

5. CONCLUSION

The relationship between humans and technology is complex and multifaceted. Since our earliest times, we have used tools, laying the groundwork for various technological inventions. During the late Middle Ages and the early Renaissance period in Europe, through Gutenberg's press, humanity democratized access to knowledge and information that later led to serious societal changes, leading up to the creation of digital codes and thinking machines in the modern world. But with great technologies comes great power, and there is a serious potential for harm if such technologies are misunderstood and uncritically used. Digital technology has great potential to aid humanity, but we must not allow the full transfer of the mind's faculties into digital hardware. We are far from certain about the long-term effects of digital devices, media, and services on the human mind, but some short-term studies demonstrate that they can powerfully disrupt our cognitive processes, academic performance, mental and physical health. For that reason, we need to stay vigilant, critical, and cautious in the future use and development of digital technology.

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