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Interface takes command. Educational environments, tools and practices to face the new normal.

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Abstract | The Covid–19 pandemic has underlined the new role of digital experience in everyday life. Nowadays, pedagogy and digital technologies should be investigated in order to educate young people to produce knowledge and not to uncritically consume digital products. The development of digital technologies like AR or VR – applied to teaching and learning – is providing an exciting opportunity to design realistic, authentic, engaging and extremely fun learning environments in a broad way. Because of this, the gap between physical places and virtual spaces seems to disappear. The interface between human and computer is an essential part of this process, providing technology accessibility and new approaches to learning and teaching. By the development of increasingly pervasive digital technologies, it is undeniable that the interface, from its first forms of GUI, to TUI, VR, or AR has become a tool capable to blend the differences between the two worlds – tangible and intangible – looking for a fusion that is very close at the moment.

KEYWORDS | INTERFACES, PEDAGOGY, NEW NORMAL, EDUCATIONAL ENVIRONMENTS, DIGITAL TECHNOLOGIES

Premise

The following contribution intends to provide an overview on the contemporary interface project as generator of environments in the educational field as answer to the new skill requested by the digital revolution society and the new normal after Covid-19 pandemic. In particular, paragraph two presents a theoretical overview and key to understanding the whole contribution; emphasis is placed – on the one hand – on the definition of interface as an environment and design of culture – on the other hand – we focus on the possible effects and potential of mixed reality interfaces in the field of education. Paragraph three – instead – presents a series of best practices related to the educational field divided by the ability of the interface to be a driver of environments or vice versa, by reviewing Tangible Interfaces projects up to immersive learning spaces.

1. Introduction

The Covid-19 pandemic, that has spread over the entire world since the end of 2019, despite being a purely health issue, has inevitably highlighted the role of digital technologies in the life of every single person inevitably (Ting, et al., 2020). If once, the World Wide Web was considered as a parallel world – in the dichotomy between the physical and virtual one – today we should assert the overcoming of this split in favor of a single hybrid world, the information society (Floridi, 2014) and the Mixed Reality (MR) world: a condition in which the digital information are totally pervasive and layered over the physical world (Resmini, Rosati, 2011). The need for social distancing, lockdown and all the prevention and containment measures against Covid-19 have influenced the social, cultural and behavioral aspects of all humanity (Nicola, et al., 2020).

For this reason, pedagogy and digital technologies should be investigated in order to educate young people to produce knowledge and not to uncritically consume digital products. No one can deny that smartphones play a central role not only in our lives but also in children's one (Maes, 2019). Digital Revolution is gradually changing different aspects of material and immaterial society by the ubiquitous Internet, IoT and ICT (Bollini, Caccamo, Martino, 2019). Nevertheless, as Maes states (2019), we live in an illusory dichotomy between parallel worlds: the tangible physical world and the intangible digital one mediated by a theatrical wall (Laurel, 2013) – the interface – enclosed in the palm of our hand.

On one hand, the traditional pedagogical systems seem to be unable to attract youngsters. Accustomed to look beyond the textbook, they are fascinated by what allows them to enter into the subjects. In order to do this, one of the keys is the use of non-invasive but additive technologies, such as Mixed Reality – AR or VR. The power of these technologies – applied to the environment – is their ability to design functional spaces based on physicality, construction and imagination (Årlemalm, 2006; FjØrtoft, 2004).

The development of digital technologies like AR or VR – applied to teaching and learning – is providing an exciting opportunity to design realistic, authentic, engaging and extremely fun

learning environments (Kirkley, Kirkley, 2004) in a broad way. Because of this, the gap between physical places and virtual spaces seems to disappear. During the last decades, different pedagogical approaches that combine technology and education have been developed, such as Digital Object Based Learning (Chatterjee & Hannan, 2015), Visual Thinking (Housen, 2002), and Digital Storytelling (Rappaport & Liguori, 2019). All these approaches are characterized by an active involvement of the people. In addition, it should be also considered how the web and related technologies affect the sensorial, perceptual and behavioral relation between children and educational objects.

2. Theoretical background and main concepts

2.1 Interface: a contemporary definition

Due to the strong influence of the disciplines from the Human Computer Interaction, the cognitive psychological to the engineering sciences (Pold, 2005), the concept itself of interface has been declined in its purely functional meaning, i.e., as the tool able to make man and machine communicate in order to achieve the intended task. This approach reflects the will of invisibility that Norman (1990) affirmed as the ultimate goal of achieving perfect affordance, underlining how the interface's problem is itself the interface (Norman in Pold, 2005). Nevertheless, neutrality is impossible. Because the interface "is designed within a cultural context and at the same time designs cultural contexts" (Interface Manifesto, 2015). This approach can be seen from the beginning of the Graphic User Interface. The interface design has always borrowed the concept of environment, first through rhetorical forms of spatiality – such as the WIMP interface – until today in which digital technologies such as Virtual or Augmented Reality allow interfaces to be designed as environments and to actually interact with the surrounding space. But is the interface an environment?

“we look at interface as a thing, a representation of a computational process that make it convenient for us to interact with what is really happening. But the interface is a mediating structure [...] it is a space between humans and procedures [...] and determinates what can be done in any digital environment”. (Drucker, 2014, pp.138–139)

Drucker's theory (2014) turns out to be the natural evolution of the intuition that Gudrin (1989) had theorized. Gudrin – in fact – affirmed that different forms of interface – terminal, functional, software, dialogical – and ultimately social have followed one another in history, thus underlining its pervasiveness towards the environment. According to Manovich (2001) and as reiterated within the Interface Manifesto (2015) today we could say that the interface – in a broad sense – has reached the level of Culture, as it is not a mere tool of *man-machine communication* but has become the main communication medium between men (Johnson, 1997), as well as a tool capable to design culture. More than before – due to the Covid-19 pandemic – we use the interfaces to talk with other people through social media, discuss

about works by Skype and produce culture, for example digital art, books and so on. Finally, we design interfaces by using other interfaces (Manovich, 2010).

From a metaphorical point of view, analyzing the relationship between interface and environment, we could also introduce the terms of movement and corporality in the use of the interface. In general, the design of a GUI or of the UX of a digital product is nothing more than the design of the movements in a given space – virtual or not – of a single or multiple users. Laurel (2013) in this regard, creates an interesting parallel between the interface design and the theatrical project. Analyzing, in fact, it is possible to find at least three points of contact between the theatrical world and the interfaces one: stage / background, interaction, metaphor. Both show a touch point, in which the action takes place (the UI), and a backstage, which supports the structure (the architecture and the back end). From the interaction point of view, this process – in the theatre – can be seen both as the interaction between the actors on the stage and also on the empathic relation between actors and public/user. In the interface world, this process is attributable to the design of the interaction. Lastly – the clearest – theatre and interface, as mentioned, are based on rhetorical systems able to reflect us from one world to another, managing to break down the barrier as long as they are used.

Thanks to the development of increasingly pervasive digital technologies, it is undeniable that the interface, from its first forms of GUI, to TUI, VR, or AR has become a tool capable to blend the differences between the two worlds – tangible and intangible – looking for a fusion that is very close at the moment.

In order to understand the relationships between digital physical and digital environment, it is necessary to mention the "*Reality–Virtuality Continuum*" scheme by Milgram (1994). The scheme is a scale that moves from a completely real environment up to a completely virtual one. The space between physicality and its virtualization of the environment is defined by Milgram: *Mixed Reality* (MR). It is the place of interaction and intersection between the real environment and the virtual one at progressive point mitigated by technology. Using Mixed Reality, the hybrid real–virtual environment takes concrete form, and the interface becomes a generator of environments.

The interface is a *media* (Manovich, 2001), which mediates and filters between data, algorithms, coding languages and humans. It is a *cultural action* in which we produce culture using interfaces (Manovich, 2010) and form the world. For this reason, the Milgram scheme can be updated with the Mann scheme (2006) in which the mediation value of technologies respect to the environment is highlighted. It is a matrix system that shows the greater complexity of the physical–virtual relationship, compared to a "purely" linear system. We live thought interfaces and thanks to them we communicate, work, get excited, learn and grow (Pold, Anderson, 2018). More and more information will be accessible to us. Only by the use of new forms of MR, we'll be able to balance the constant growth of knowledge, accessibility and dissemination of contents (Samit, 2019), thanks to an intelligent environment able to communicate with us. Starting from these considerations, it is

deducible that education could be seen as a fertile ground for the applications of MR technologies.

2.2 The interface as driver for education

Contemporary society – called society 4.0 – is the society of the digital revolution. Increasingly accessible technologies that allow us to open new horizons and new ways of living and experiencing life. A complex society that requires inhabitants to have complex skills accessible to everyone. There is a evident research for innovative pedagogical tools to meet the skills demand of the current and future society. As stated by Fullan & Langworthy (2013), interesting and new forms of pedagogy are taking hold thanks to the intersection of *design–technology–education*. In this context:

"The interface between human and computer is an essential part of this process, providing technology accessibility and new approaches to learning and teaching" (Starčić, Turk and Zajc, 2015)

In fact, today, we are able to understand and shape the surrounding world by interfaces (Interface Manifesto, 2015). The new digital technologies open up new scenarios and contexts of education that move away from the classroom format (Starčić, Turk and Zajc, 2015), to different, customized and immersive realities, both in term of content and users. Among these, the growing demand for personalized educational supports within museum contexts capable of implementing curiosity, attraction and developing critical thinking through a re–reading of the collections present in museums (Poce, Amenduni, De Medio, Valente and Re, 2019).

Education should be considered the basis of a society that aims to create a better, sustainable, responsible and conscious future (World Economic Forum, 2018). Education is the first step towards evolution. As can be read within the programmatic lines of the Italian Digital Schools National Plan (Piano Nazionale Scuola Digitale, 2015), the introduction of digital technologies in the educational field is first and foremost a cultural action, based on a new concept of school intended as an open space for learning and not just a physical place. In this paradigm, technologies become enabling, daily, ordinary. So, Do MR interfaces enhance education?

Educators who see technology in action immediately recognize its potential to engage, educate and entertain (Parlier, 2019). There is numerous scientific literature that testifies the use of Mixed Reality technologies in educational contexts. Nevertheless, the state of current MR research for education is still in its infancy (Bacca, et al, 2014; Wu, et al., 2013, Cheng & Tsai, 2012). According to (Ninorean et al., 2013) despite of the numerous previous studies have shown a positive impact and encouraging results in the use of MR technologies in the educational field, scientific research must now move towards a pedagogical and learning theory linked to the implementation and development of MR tools. The educational value of digital technologies such as virtual, augmented reality and so on, cannot be based

exclusively on their specific characteristics. Many themes must be investigated in terms of aesthetics, characteristics and peculiarities that these technologies can give compared to other mediums (Bacca, et al., 2014). First of all, the interaction–relationship with the surrounding space. The study conducted by the Computer Education and Instructional Technologies departments of the Universities of Kırıkkale and Gazi in Turkey (2017), highlighted the pedagogical role of the introduction of the MR in the band called K–12 of teaching. Within the research work, different AR applications in education were analysed and the potential of new digital technologies has been brought to light. In the report, citing Chang et al. (2014) it is found that AR is able to increase the level of attention towards the topics covered. In another study by Dunleavy et al. (2009) – contained in the Turkish research project – AR technology via mobile device has facilitated collaborative learning in hybrid learning environments. Lastly, Liu and Thai (2013) through a multisensory AR system based on the sight, hearing, speech and movement of the whole body of the students, were able to increase the physical activity of the students by improving their motor skills.

The possibilities offered by these technologies allow to increase the knowledge of traditional supports, which as stated by Sun, Wu, Fan, Dong (2019), are bound to the limits of the two dimensions, favoring instead a third or even fourth dimension, in order to boost imagine engaging, immersive and multimodal learning processes. In fact, the power of MR technologies resides in the local ability to generate environments with latent information and content (Samit, 2019).

“Learning becomes more enjoyable and effective, even when it comes to exploring and knowing abstract concepts or complex phenomena, and this thanks to the possibilities of visualization and realization of the concepts that this technology makes accessible to the learner”. (Klopfer & Squire in Elmquaddem, 2019, p. 238).

If on the one hand the need for a tangible experience is highly recommended, at the same time it is required to innovate pedagogical tools capable of making the best use of the power that new digital technologies expect to have. Products and environments developed in MR – as we will see in the examples in the following paragraphs – could become the test of the new way of experiencing a complex reality in a digital society on top of the maturity (Baricco, 2018) made of the info–tangible diversity and the info–intangible one. Therefore, the role of educational interfaces in MR becomes transmitting culture, which in accordance with Bruner (1996) is the "toolbox" given for adaptation to civilization, a way of solving crises and problems.

3. Best practices and state of the art

The interface – as stated in the previous paragraphs – shows capabilities that go beyond mere functionality. It constitutes the main medium of contemporaneity (Andersen, Pold, 2018) and the most important cultural form of our century (Johnson, 1997). The strength of the interface lies in its ability to be multi–media, i.e., in its nature of re–mediation (Bolter,

Grusin, 1999) of classic and contemporary media – texts, images, videos, sounds within a new form and attractiveness. It is no coincidence that we understand how education – driven by the need to innovate its pedagogical protocols – sought to make use of the interface as a pedagogical driver. Education, in fact, places in the interface the value of cultural leverage and promotion of critical thinking, analysis, and in general, of the new contemporary skills.

The interfaces that will be presented in the following paragraphs can be represented by an inversely proportional linear scheme in which the relationship between environment and interface is interpenetrated and modulated. If on the one hand, the Tangible User Interface, have the ability to generate and control a digital interaction environment through the manipulation of reality (Ishii, 2006), on the other hand, multisensory environments and in general the interactive environments make use of the environment itself to become the interface with which the user can interact both physically and emotionally. Both forms start from the consideration of the role of the sense and of the body in the interaction and educational process (Kim & Maher, 2008), demonstrating effectiveness in terms of cognitive impact, improvement of analysis and criticism skills both in standard subjects and in subjects suffering from cognitive disabilities. Movement is an integral part of a child's psycho-physical process. Since "it is not enough to simply accept that play is important in education" (Waller et al., 2010), it is necessary to rethink what it represents for a child to play in the 21st century (Änggård, 2017).

3.1 When an interface acts as an environment

The ifs | 2020

Gaming is a fundamental activity for the solid construction of bases capable of increasing various factors of brain development, both as regard social and communication skills, as well as emotions and cognitive and physical abilities (Mastrangelo, 2009). The ifs ¹ is a project currently in the crowdfunding phase, which compared to the following cases is characterized by its totally tangible nature. The educational set has the aim of teaching the basics of coding without the use of digital displays, but by using tactile interfaces only. As we can guess from the name – the ifs – the logic of the game is to convey the concepts of action and reaction – if and then – through the intrinsic perceptual characteristics of the individual robots: sensitivity to sounds, touch, light. By leveraging imagination and creativity, children have the opportunity to learn coding and improve logical thinking, teamwork, creativity and notions of robotics. The robots can be programmed both in the *IF* condition and in the *Then* condition, thus increasing the possibilities and combinations of interactions ².

¹ www.theifs.cc

² <https://youtu.be/AcZIN3hAf6k>

Tangiplay | 2019

Computational thinking is recognized as a necessary skill for everyone (Wing, 2006), by virtue of this, there are numerous products that, by an analog / digital relationship, teach the foundations of a new language that is an integral part of the digital literacy of the new generations. Within the range of products available on the market, Tangiplay³ is certainly one of the most interesting. Developed through a crowdfunding campaign in 2019 and winner of the IF Design Award 2020, the game aims to teach the fundamentals of coding – sequencing, condition, function, loop – using coloured puppets as physical controllers of the activities available on the tablet. Children – from 4 to 12 years old – have the task of designing a railway track capable of going from point A to point B: the metaphor of a code string. The individual puppets – chromatically divided by function – are used as programming elements, defining the route that the train will have to take. When they press, slide, or rotate the robot, this translates into code that creates a unique response in the game.⁴ What children do is the logical transcription of an algorithm, understanding the logical basis of the coding language.

Project Zanzibar | 2018

The blending of physical and digital interfaces has the promise of creating more fluid, dynamic, and ultimately engaging user experiences (Spadacini, McDonald, 2017). This is the goal that the Microsoft Research team has set itself in the development of Project Zanzibar⁵, unveiled in mid-2018. The idea of the project is that of a polymeric capacitive platform – a sort of flexible and portable pad – capable of detecting objects, connecting them and perceiving their contact with the user's hand. The technology behind this project is a combination of capacitive sensing and the NFC protocol, allowing the touch and mouse to coexist with the manipulation and control of physical objects. Every single object present in Project Zanzibar is listed through a unique ID, which is therefore able to keep track of all data – movement, rotation, pressure – thus archiving the history of the individual object. Children use the individual objects on the pad as a tangible interface by manipulating and controlling the related digital avatars on the pad. In addition to semantically neutral objects – therefore capable of being used within the platform without alternating their content – there are semantically active objects, whose presence changes the digital environment. The introduction – for example – of a palm-object interferes in the digital context by changing the scene⁶.

³ www.tangiplay.com

⁴ <https://youtu.be/QjyzutQU0v0>

⁵ www.microsoft.com/en-us/research/project/project-zanzibar/

⁶ <https://youtu.be/4G16iaVXZu0>

3.2 When an environment acts as an interface

In Tune with Nature | 2019

Museum systems are among the most active promoters of new technologies related to the learning and use of cultural content (Poce, Re, Amenduni, De Medio, Valente, 2019). Immersive and augmented experiences are now proposed to different target users with the desire to enrich the cultural heritage of the museum itself. Outdoor contexts are re-proposed in a digital key, offering learning opportunities and thematic focuses that are not always achievable through a purely tangible experience. With this in mind, the project created inside the Cayton Children's Museum in Santa Monica, entitled In Tune with Nature⁷ should be read as an immersive room in which experiencing the natural cycles of day and night. The underlying technology is the consolidated projection mapping with motion sensing. Children find themselves projected into different natural contexts, analyzing and understanding the changes in the elements over time⁸. In addition to the interaction factor, the work done – in terms of the visual language of the illustrations – is interesting: combining fidelity of detail with formal dryness.

Interactive Immersive Classroom | 2018

The educational environment par excellence – the classroom – is also undergoing a revolution thanks to the advent of digital technologies (Oke, A., Fernandes, F.A.P., 2020). In fact, we are moving from a purely frontal form of teaching to an "experience" of teaching that involves all the senses to improve attractiveness and critical thinking. This is the mission of *Interactive Immersive Classroom*⁹ a teacher-friendly system that offers customized experiences for teaching. The strength of the project lies both in the availability of content – opensource library, as well as content selected from streaming platforms such as youtube.com – and in the total immersion of the classroom. The system is also extremely flexible based on the contexts of use, meeting the different architectural settings that arise from time to time within the schools. Designed for the teacher, it becomes an active teaching support for selection – display – validate the teaching content. Furthermore, immersion guarantees a high level of engagement and attention threshold, managing to effectively convey complex concepts, for example regarding the teaching of STEAMs¹⁰.

Lü – Interactive Playground | 2017

Interactive projection mapping systems combined with motion capture are certainly not new in the education sector. Despite this, the Lü – Interactive Playground¹¹ project has two important structural features: on the one hand, the possibility of adapting the technological

⁷ www.ideum.com/portfolio/in-tune-immersive-room

⁸ <https://youtu.be/TqRu-oGFM6I>

⁹ www.immersiveclassroom.one

¹⁰ <https://youtu.be/TCD3H70o5B8>

¹¹ www.play-lu.com

configuration according to the needs of the space in which it will be installed, and on the other, to offer a very wide platform of activities that allows educators and children to always make new experiences. Through the combination of projectors, Xbox Kinect, and sound and light systems, Lü allows to increase the canonical environments of the school – like a gym – without altering the physical–spatial structure. Depending on the configuration chosen, it is possible to obtain more or less immersive environments in which children can play interacting tangibly with the contents projected on the walls. It is possible – for example – to play an off–scale version of space invaders by using a ball as a weapon to destroy spaceships¹². The goal of the project is to create new pedagogical forms, looking for a fruitful relationship between mind – body – emotions.

4. Conclusion

What has been described is intended to be an attempt to reconstruct a conceptual framework and a preliminary state of the art regarding the design of digital supports for the implementation of contemporary pedagogy. In particular, it emerges how much Design – can be an interpreter of contemporary processes and a "designer" of languages, able to adapt the interaction to the new pedagogical needs that characterize "society 4.0" in terms of critical, analytical and coding skills. The cases described, show that It is necessary, and it is possible, to bridge the gap between physical and virtual fruition, leveraging the elements of storytelling, involvement, interaction and experience, in order to develop fundamental skills in people – such as Critical Thinking (Poce & Re, 2019) – in educational context.

It is deduced that the big question is how to generate awareness and knowledge – with all the appropriate afferents – in the new generations through new educational approaches that integrate physical spaces with virtual interactions, educating – correctly – to a new way of conceiving the complexity of reality.

One possible strategy is to make a transposition from the video–gaming world to the educational ones through the application of gamification principles (Tayara & Yilmaz, 2020). These principles – leveraging the conceptual aspects of the game – allow to generate involvement and interest in a given theme, through narratives, the use of achievements, rewards and immersed environments. At the same time, they stimulate the so–called skills of the 21st century: Critical Thinking, Creativity, Communication and Collaboration (Qian & Clark, 2016)

The touch points between tangible and intangible – as seen in the examples shown – confirm that the interface is not really tending to disappear – as stated by Norman (1990) – how much it has managed – breaking the screen – to break the so–called "fourth wall"

¹² <https://youtu.be/qAaZ7-fJv0s>

(Caccamo, Mariani, 2020) of its theatricality, opening to a new era of interaction that involves all the senses and the surrounding space thanks to technologies.

The cultural sector – schools, museums, theatres, cultural centres – had to face the question of remote or hybrid fruition both for economic reasons and mainly because of the role of Culture as an integral and fundamental part of people's lives; as never seen before – due to the Covid–19 pandemic – *Culture* had to convert and adapt its way to communicate and mediate information to a new reality (Shaker, 2020).

So, If – therefore – reality and virtuality can coexist thanks to the development of digital technologies, design the education of the new normal will mean designing interfaces: tangible, multimodal, widespread–accessible and narrative (Caccamo, Mariani, 2020).

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