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USER EXPERIENCE AND INTERACTION DESIGN IN CREATIVE PROCESSES AND EDUCATIONAL SCIENCES WITH VIRTUAL AND AUGMENTED REALITY TECHNOLOGIES. A RESEARCH WITH QUANTITATIVE AND QUALITATIVE METHODS

Experiencia de usuario y diseño de interacciones en procesos creativos y ciencias educativas con tecnologías de realidad virtual y aumentada. Una investigación con métodos cuantitativos y cualitativos

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SUMMARY: Virtual, augmented or mixed reality, are nowadays part of a new emerging generation of information and communication technologies. Their influence, since the 80's and the 90's in fields such as education, creative processes and research, has been shown in many studies since then. Those technologies have also a relevant potential to have an influence in current approaches in information and communication sciences. Thus, factors such as immersive experiences, simulation or interactivity, should be kept in mind in order to design experiences which can help us to understand the relationship between user, information, devices and environments. This manuscript shows a research based in both quantitative and qualitative methods. Quantitative research methods include surveys based on factors such as

interactions design principles, usability heuristics or technology acceptance models, among others. Qualitative ones include grounded theory and specifications such as IMS LD. Results shows how those technologies have dramatically influenced in creative processes and users' relationship with technology, peers and virtual and physical environments.

Key words: virtual reality; education; user experience; augmented reality; creativity; mixed reality.

RESUMEN: Las tecnologías de realidad virtual, aumentada o mixta, son a día de hoy parte de una generación emergente de tecnologías de la información y de la comunicación. La influencia de estas, desde la década de los 80 y de los 90 en campos como la educación, la investigación o los procesos creativos, ha sido objeto de numerosos estudios. Estas tecnologías poseen también un potencial de gran calado para ejercer una influencia en las perspectivas actuales en torno a las ciencias de la información y de la comunicación. Así, factores tales como experiencias inmersivas, simulación o interactividad deberían ser tenidas en cuenta para llevar a cabo diseños de experiencias que nos ayuden a entender la relación entre usuario, información, dispositivos y entornos. El texto actual presenta una investigación que parte de métodos tanto cuantitativos como cualitativos. Los métodos cuantitativos incluyen encuestas basadas en principios del diseño de interacciones, las heurísticas de usabilidad o los modelos de aceptación de la tecnología, entre otros. Los métodos cualitativos incluyen la teoría fundamentada o especificaciones como el IMS LD. Los resultados muestran cómo estas tecnologías han influido de manera importante en los procesos creativos y en la relación de los usuarios con la tecnología, con otros usuarios y con los entornos virtuales y físicos.

Palabras clave: realidad virtual; educación; experiencia de usuario; realidad aumentada; creatividad; realidad mixta.

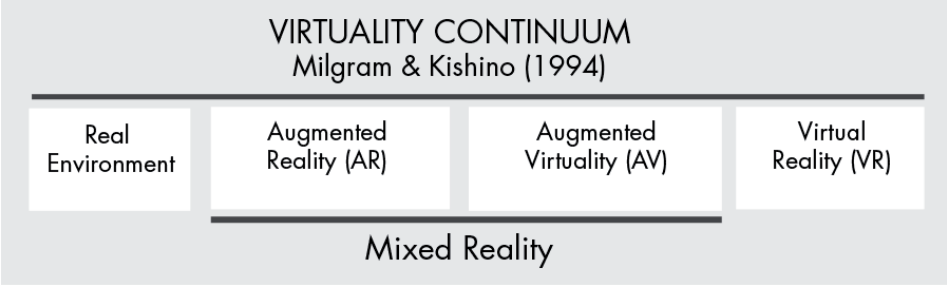
1. INTRODUCTION

Nowadays, virtual and augmented realities are key relevant elements within the Communication and Information Sciences' (ICT) context. Possibilities in those areas are relevant when we do an approach on the different factors related with ICT: interaction, simulation, user experience, immersive approaches, human-computer interaction (HCI), interaction design (IXD) or interface design, among others. A multidimensional approach is achieved when users, digital information and environments interact. In this process of interaction, different layers of the reality-virtuality continuum are interconnected and involved.

The evolution of Information and Communication Technologies (ICT) and the possibilities of the interfaces lead us to new emerging and innovative approaches on the relationship and interactive process with the information and the environment. Those new interactive approaches include image and sound, but also haptic

and kinetics, leading us to new approaches that can be applied in fields such as education. The evolution of the technologies and devices help researchers to conceive new ways for interacting and communicating with information and digital or real world environments. This fact allows, also, find new ways to integrate games, educational resources, design or art, among others.

FIGURE 1.
The virtuality continuum
Representation of the virtuality continuum, by Milgram and Kishino (1994).



2. LITERATURE REVIEW

Since the first approaches of Lanier (1992) and Lanier and Biocca (1992) in the 90s, research on virtual reality, augmented or mixed reality has focused in technological approaches and applications. Fields such as psychology (Biocca, 1996), ergonomics (Kozac *et al.*, 1993), games, robotics (Satava, 1992) or educational sciences (Psotka, 1995) have been object oof study for apply virtual, augmented or mixed reality in past decades. Nowadays technological evolution has made research in virtual reality technologies emerge. The applications in theoretical dimension, cognitive approaches or technological focus, are appropriate in areas such as video game or virtual immersive-interactive environments development, design and research, and interdisciplinary fields such as user experience or human-computer interaction, among others. Simulation and research in factors such as interaction with virtual objects and environments, and immersive approaches are also relevant, as well as theories of information and communication are key disciplines to explore new ways of interaction.

The analysis of the narrative dimension (storytelling) through technologies related to the virtuality continuum (Meyer, 1995; Ryan, 2001) started when the approaches related with the virtuality-reality continuum began. The relationship between the narrative possibilities of digital media and the technologies associated to virtual, mixed or augmented reality has been described and also analysed in theoretical approaches developed in the 90s. The evolutions of interfaces and technologies have exponentially increased and broaden the possibilities in fields

and disciplines such as the arts, educational research, or game development and design, as well as creative processes.

The creative and expressive dimensions have also evolved in the context of the technologies based on virtual, mixed or augmented reality. Those expressive and creative dimensions are then relevant for develop new approaches in educational sciences, by taking advantage of virtual reality technologies' power. Thus, virtual reality technologies and virtual environments may allow and facilitate interoperability between areas such as educational sciences, training or artistic creation. This interoperability helps also to integrate human factors, such as interaction design (IxD), affective computing or human computer interaction (HCI) to improve research in areas such as educational sciences. Research in virtual reality technology has also a relevant role for developing hybrid disciplines focusing in different application and uses of those VR technologies, especially in educational approaches and dynamics.

Virtual, augmented or mixed reality technologies have been often, since the 90s, applied to diverse research fields. Creativity is also a field where virtual reality technologies have shown many interesting progresses and applications. Those applications may have had a relevant influence in fields such as education or science.

Virtual reality and immersive environments, as well as mixed or augmented reality, imply a relationship and interaction between users and environments (physical or virtual). Those environments contain also information, and interactions depend on the way we design this information and the environment itself. Thus, an immersive or virtual environment may have a design based on a creative approach. And it has a direct relationship with the aforementioned fact of storytelling, among other.

The design of virtual environments for creative purposes has been focused since the 90's. Thus, authors such as Streitz *et al.* (1999), do an approach about artificial digital worlds for improve and study creativity. They develop, in 1999, an interactive landscape for innovation called i-Land. Another authors, such as Thorsteinsson and Page (2007), focus on relationship between creativity and education facilitated by virtual reality technologies. Zyda (2005) also analyses the relationship between virtual reality and creativity by focusing in video games and serious games.

This relationship between technology and creative processes has also relevance in research in human factors, human behaviour and interaction. Disciplines such as interaction design (IxD), human-computer interaction (HCI) or user experience (UX), among others, are intrinsically related with research in design of virtual immersive environments. Thus, when a virtual environment or a virtual reality experience is conceived, prototyped and designed, it's necessary to keep in mind factors such as ergonomics, objectives and purposes of the immersive experience, levels of interaction implemented or possibilities for implement creative processes.

The level and possibilities of interaction depend also on the evolution of technology, and virtual reality technology is getting increasingly immersive and interactive.

For that reason, aforementioned disciplines such as ux, IxD or HCI have been part of evolution of virtual (or augmented or mixed) reality. Much research has been done in those fields, such as those examples show: Bowman and McMahan (2007) pose the question about the implications of immersive power of virtual reality for designing realistic experiences. The different degrees of immersive presence is a relevant approach in their study. Riva *et al*. (2007) focus on affective dimension when using virtual reality technology, by keeping in mind the emotional factors when users are in a VR environment. Sherman and Craig (2002) try to understand the nature of virtual reality by depicting factors such as communicative power of this technology or interfaces. Other authors such as Kohler *et al.* (2011) also explore VR under the approach of user experience and interaction, and describe its possibilities for creative and collaborative dynamics.

Research in past decades show how human factors and cognitive approaches, as well as aforementioned interdisciplinary fields (UX, IxD, HCI, among others) are inherently connected to evolution of technologies and devices. Application of VR technology in fields such as education or creative/collaborative processes, needs, this way, to implement the design of experiences and learn about users' potential behaviour.

2.1. *State of the art*

The evolution of digital devices, interaction possibilities and the complexity in virtual environments allow new opportunities in the creative processes, through the developments of new ways of narrative and storytelling. The complexity and sophistication of the interaction surface (interface) between individuals and machines make new ways of communication possible, and virtual environments became laboratories for new experiences. The range of application in several disciplines, such as education, fine arts, advertising, sciences, or engineering –the STEAM context, acronym of *Science*, *Technology*, *Engineering*, *Arts and Maths*– is giving rise to emerging frameworks of research and knowledge. Applications in those emerging frameworks are observed along the virtuality continuum. This makes possible to find creative and innovative gaps in virtual, mixed or augmented reality and to apply them in the aforementioned fields. The transformation of the notion of «environment» through the concept of simulation, interaction or the different levels or approaches of immersion (visual, sound, haptic or proprioceptive input) lead to innovative artistic, narrative or storytelling expressions, which can be applied in different fields of research –scientific, educational or technological. This virtuality continuum approach allows the accomplishment of research projects in different areas such as the development of intelligent learning environments (González Aspera & Chávez Hernández, 2011), as well as applications in the health sciences –e.g. mental health (Gregg

& Tarrier, 2007) or accessibility (Hughes *et al.*, 2009). Those new explorations of creative and innovative possibilities of virtual information, objects and environments, lead us to new approaches when designing activities for museums or cultural heritage sites. Augmented reality nowadays allows to represent in a real or fictional way interactive events, in order to preserve, maintain and represent cultural and historical heritage (Chang & Liu, 2013; Ruiz-Torres, 2011). We can also integrate alternate reality games (or ARGs) in the real world using augmented and mixed reality technologies, in order to provide a more involving interaction with the virtual information (Bakioglu, 2015). Approaches around sound and musical experiences in virtual environments are also relevant in this research, due to the role of the sound in virtualiy continuum and immersive experiences in virtual and mixed environments (Gértrudix Barrio & Gertrúdix Barrio, 2012). Sound is, therefore, an essential component in spatial perception and acts as an effective tool in the development of the virtual environments.

There are several ground-breaking projects based on virtual, mixed or augmented realities. Current technologies and devices allow reconfiguring the relationships between the information and the environment. Innovative projects such as Word Lens allow translating in real time signs in real world, by means of an AR application. Other tools, such as *Eyewriter*, allow people suffering reduced mobility to create gratifies and other forms of art. The tool is based on eye-tracking technologies to draw lines in space, mixing principles of science, art and technology. On the other hand, virtual environments are studied and researched in order to innovate collaborative online collaborations. In line with this approaches, nowadays there are several virtual platforms based on virtual reality (e.g. *Virtalis*), that allow professionals with different backgrounds to work in a shared project. Factors such as motivation, performance or design are also kept in mind when improving the interactive experience (Castaño Garrido *et al.*, 2015).

McLuhan (1967) stated that the medium is the message. Nowadays, the medium achieves new dimensions and approaches thorough the virtuality continuum. Message can then be, under this approach, multidirectional emergent interactive processes, involving diverse cognitive and perceptual dimensions.

Therefore, the aim of this research is to contribute to the establishment of principles to fix the new frameworks of relationship between individuals and technologies. The virtuality continuum is, under this approach, an experimental laboratory that allows new experiences and research about innovative interaction and artistic creation processes. Virtual, mixed and augmented environments and objects have countless possibilities for transmedia storytelling or user experience, being an interesting and suitable object of study nowadays.

3. Methodology

The methodological framework address, from different focuses and approaches the relationship between technology, users, digital and physical environments

and creative processes. Different techniques and instruments are used in current research (Venkatesh *et al.*, 2013), including both quantitative and qualitative ones. Methodology is also focused in an approach based on the virtuality continuum. Thus, video games, robotics, virtual immersive environments or augmented reality, among others, are components wich are part of the virtuality continumm approach. And those components are essential research items when analysing the new applications in scientific, educational or artistic domains.

First of all, a sample of 30 experts in media and technologies are interviewed. The questions are focused in technologies based on the virtuality continumm, such as virtual reality, augmented reality, serious digital games or robotics. These professionals develop their activities with technologies in medialabs, digital labs in universities or digital culture research centres, among others. Thus, their activity is based on research in applying media and technology to educational or communicative domains.

The survey is based on factors such as UX, IxD or HCI. Other theories based on self-perception, such as Technology Acceptance Model (TAM) (Davis, 1989), the motivational model (MM), the theory of reasoned action (TRA) (Mishra *et al.*, 2014) or personal innovativeness (Agarwal & Prasad, 1998) are taken into account.

Those theories have been used to design surveys that evaluate the knowledge and use of virtual reality, augmented reality, devices and digital environments for creative purposes. The objects evaluated include: game engines, serious games, virtual reality, hardware devices (especially open source ones), and augmented reality or development environments for programming (IDE), among others. Their perceived usefulness and user friendliness, which are an important part of TAM theoretical approach, have been kept in mind when designing the questionnaires for this study. The fieldwork has been conducted using a self-administered questionnaire which comprises: in one hand, 24 questions (by keeping in mind the TAM, MM or UX approaches), in Likert scale, measuring degree and attitudes of conformity and, in the other hand, 6 open-answer questions. We have finally obtained 40 variables during the research, both quantitative and qualitative.

The questionnaire was designed to measure 40 variables, both quantitative and qualitative. Variables 1 to 15 analysed the techniques of creativity to develop projects. Variables 16 to 22 evaluated the relationship between creative development, activities performed and technologies used. Variables 23 to 29 examined the use of Augmented Reality from the perspective of the Technology Acceptance Model. In these three blocks we have consulted the degree of agreement or disagreement with the expressions reactive on a likert scale. Variables 30 and 31 used Open-Ended Responses to inquire about Which Augmented Reality tools and software have you commonly used, and which Augmented Reality Technologies would you like to use in future projects, respectively. From these we have generated a list of technologies commonly used. The last block, which contains the variables 32 to 40, analyzes the perception about Usage of Virtual Reality and Serious Games from the perspective of the Technology acceptance model (TAM) through, again, the

expression of the degree of agreement or disagreement with the reactive expressions on a likert scale.

Secondly, we analyse 60 projects in twelve medialabs, fablabs, digital research labs in universities and digital culture research centres. To represent the different components of this analysis and distribute them by categories, we use specifications and diagrams described in the following paragraphs. Phases of narrative scenarios in those projects have been used, by approaching the metaphor of theatre to represent components and structure. Those scenarios include and integrate diverse elements, as follow: role, activities, environment, objects and objectives, among others. Other practices are also being used to reconstruct those scenarios after observing the dynamic processes in projects analysed in this paper. The reconstruction of procedures and components described in this paragraph needs to use and apply specifications and standards that allow visually representing this scenario. Thus, to outline the components of the Unified Modelling Language (UML), IMS Learning Design (IMS LD) specifications have been applied (IMS Learning Design Consortium, 2003, 2014; Burgos & Koper, 2014).

From them, dynamic displays, models and mental mappings are developed, using several digital data visualization tools. We conceive also, by using those models, scenarios for innovative interaction, where digital technology, creative and innovative processes with educational purposes, converges. By developing visual schemas and specifications describing dynamics of those projects we aim to differentiate the components and analyse how they interact.

Interactivity and interactions between users and technologies reveal a relevant relationship with virtual reality technologies (as well and AR or mixed reality) and creative processes. In this process many relevant factors related with those technologies are kept in mind since beginning, as follow: simulation, relationship between different information layers (comprising virtual, real or mixed ones) and the environment itself, immersive potential and features (in the case of VR), interaction (and interactivity), as well as the potential of a physical or virtual component or object to be transformed or manipulated by users, among others.

The technologies have been divided and classified in the following taxonomical groups: augmented reality tools, virtual reality tools, digital serious games (augmented reality games, digital video games and immersive games) or open source hardware tools. The interaction between the users, the environment and the digital information reveal the possibilities of those technologies in several areas. This fact is relevant in educational domains and sciences, where several components that influence the conception and design of the interactive environment such as the individuals, the content, and the context, are observed.

The use of information and communication technologies (ICTs) integrates factors such as gameplay or interactivity in virtual environments. Those ones are studied in areas such as e.g. educational sciences, through the emotional approach of experiences (Yengin, 2011). The dimension of the emerging hardware technologies acquires an important role due to the emergence of components that influence the

construction of space itself. This dimension has a strong link with the physic domain in the virtuality continuum, and shows how technologies are also innovative. Free hardware (like Arduino), 3D printers and technological kits allow the increasing levels of individuals who interact within the virtuality continuum through physical objects and devices. Haptic technologies or robotics exploring the potential of developing activities with a constructivist approach in the physical space (Frangou *et al.*, 2008) contribute to increase diversity in the virtuality continuum area, which is related with physical space. Open source hardware and robotics are also used in the educational and innovation related constructivist approaches, as tools to, for instance, research in solving open solution problems with a heuristic approach (Guimarães *et al.*, 2014). Those examples show a research framework where physical devices and virtual environments increase the levels of interaction. Different technologies take part in this multidirectional interaction framework, influenced by a STEAM context and having a high potential level for research in heuristics.

Some of the processes are also analysed using dynamic methodologies to conceptualize intervention strategies, such as the design-based research or DBR (Anderson & Shattuck, 2012) research methodology. The area in which information and communication sciences are framed and converge with educational sciences show perspectives on complex processes phenomena. It is necessary to keep in mind different factors in specific educational or interactive scenarios: ergonomics, emotional dimension, nature and idiosyncrasy of environment, the technology used for interaction and representation of virtual environments, levels of interaction (visual, sound, haptics), the objectives of the activity, or the potential to carry out constructivist activities, as well as the planned activities. The framework demarcating all those phenomena is taken as a complex system where interactions between stakeholders, environment, physical and virtual objects and devices turn every context analysed into a unique ecosystem. However, it is possible to infer conclusions by applying the qualitative method (DBR) to complete quantitative research used in the main part of this work. It is then possible to compare the dynamics of some of the environments studied to other environments, contributing to the development of new scenarios in STEAM areas for educational, artistic and research purposes. Tools used for innovation can be methodologies (e.g. based on constructivist approaches) and technologies framed in the virtuality continuum (e.g. video games, alternate reality games, 3D experimental game programming, virtual immersion, motion sensing input devices, head-mounted displays, open source hardware components, etc.).

TABLE 1
Relationship between questions, procedures and research techniques in our methodological approach

QUESTIONS	PROCEDURE	TECHNIQUES
Descriptive analyse of projects performed in digital laboratories and medialabs, where technologies related with the virtuality continuum are identified.	Analysis of descriptive content through the study of heuristic and constructivist projects using technologies in the virtuality continuum approach.	Grounded theory (Inductive approach).
Identify the components of creative interactive processes where technologies related with virtuality continuum are involved.	Identify elements: – Roles. – Environments. – Objectives. – Activities.	Modelling Languages (UML). Specifications (IMS Learning Design). Data visualization tools.
Identify perception on performance in creative and interactive processes, where virtuality continuum technologies are involved.	Survey to professionals developing their activities in the STEAM context.	Interaction Design Principles. Usability Heuristics. Human-computer interaction. Technology acceptance model. Therory of Reasoned action. Motivational Model. Personal Innovativeness.
Make a descriptive approach of the creative and constructivist approaches through virtuality continuum approach technologies.	Analysis of processes and identification of interaction dynamics with technologies (in creative process context).	Design-based research (DBR).

4. RESULTS

4.1. *Experimental context of virtuality continuum: interaction, simulation and extension of information layers*

The research and the conceptual approach in this area have dramatically evolved in recent years. Digital technologies have, since years, approached and reached to new milestones, and virtual reality or robotics are relevant examples of research in applying ICTs to domains such as education or science. The information is nowadays multidirectional, and technologies are more and more interactive, leading users to a wider range of possibilities when interacting with a device and/

or a virtual environment. Nowadays there are several information layers and levels, and we can interact with information under different approaches.

Digital technologies and research domains are nowadays been focused under an approach based on hybridization. Digital information, digital and physic environments and devices are nowadays components allowing us to design interactive scenarios for educational purposes. This hybridization can be also observed in the disciplines when we implement digital technologies. Thus, research in education lead us to concepts such as STEAM, when we can observe a convergence between disciplines and domains. This STEAM context involves cognitive factors, creative processes, HCI or interfaces, and focus especially in some concepts such as simulation or interaction, as well as immersive approaches.

Results show a relative high rate of acceptance (in a 1-5 Liket scale) when we analyse how users perceive the contribution and role of technologies to generate ideas and improve the creative process. Values show high rates (4,80/5) when users perceive that interaction with peers and collaborative work strengthens the creative production and the generation of ideas.

Other technological taxonomical groups such as game engines, integrated development environments (IDE) or digital video games, have a relative high rate of perceived usefulness and ease-to-use (Davis, 1989) related to the creative processes and contribution to development of ideas. High rates are also shown in the variables related with the perceived ease to use for immersive 2D and 3D environments (with values showing 4.10 and 4.00 respectively). Other relevant factors which strengthen creative production and help to generate innovative ideas are the games (4.34), specially digital video games.

4.2. *Approaching future scenarios and frameworks of technology: simulation and collaborative environments*

In a scenario where technology is conceived as a medium, as a sophisticate audio visual aid, it is necessary to continue lines of research to further analyse the relationship between the virtual, augmented and mixed reality, as well as the real world. Since individuals and the conception of environment change with virtual, augmented and mixed realities, activities can also change and become more heterogeneous, thus opening new fields of research. The use of virtual or augmented reality, integrated development environments or video games and game engines are useful tools to apply in scientific research, as well as in the production of new discourses and symbols related to human communication and the arts. Both virtual reality and the environments, together with their interactive and immersive power, explore new ways of communicating and new concepts linked to information theory. Virtuality continuum elements are not only a mean of communication, but a wide variety of communication media and information technologies. The virtuality continuum is also a concept that multiplies possibilities of artistic creation in the digital domains. The study of the processes on how to generate content and

information is also relevant to analyse the impact of virtual environments and virtual technologies. Since Milgram and Kishino (1992) define in the 80's and 90's, the traits that characterize the virtuality continuum or technology, has developed quickly in the past two decades.

Nowadays, new uses and applications for virtual reality, immersive environments, digital video games, augmented reality or open source hardware, among others, have been implemented in several research fields, such as education, training or research.

Working environments can also be simulated with technologies such as the aforementioned *Virtalis* Project. Immersion, as aforesaid, is another relevant element in studies based on virtual technologies, to develop research methodologies and interpret results. Immersion is also associated, on the other hand, with the ability of technological devices to transfer the user to a virtual space. This ability involves several interaction levels that provide information about perception: sight, hearing, haptic, kinaesthetic or balance. These environments can be applied to scientific research, education or artistic production. The environment becomes more dynamic as digital technologies and devices develop and it opens possibilities never seen before in several research fields.

Disciplines such as UX have performed a relevant role in the design of applications for dynamic and interactive environments with technologies such as virtual reality and immersive environments. This domain (UX) together with others (research in ergonomics, IxD, HCI, affective computing) brings together the relationship and connection between the user, the environment, the content, and the components. It also considers ergonomics and psychological features since it is a methodology interdisciplinary research field. The exponential growing of the interactive possibilities between individuals, virtual environments and contents open a wide variety of options in narrative, communicative, information and gaming. Developing stories through the study of the narrative (storytelling) dimension also enables research strategies to incorporate the user experience. Virtual spaces then become a support for the experimental development of non-linear narratives and new multidirectional ways of communicating. As opposed to linear storylines found in the audio visual narrative, the virtuality continuum enables a higher degree of influence in the environment and the objects. This allows activities, which may have a relevant impact in the virtual environment, to be developed. It does as well help the user to take part in his/her own open storyline –such as, for instance, in the case of video games. That degree of operation allows the exercise of activities that may have a particular impact in the virtual space, and then in other applications based on the virtual space. Dynamic linear structures break in audio visual formats, giving way to new transmedia relationships with storylines in virtual environments. One of the earliest examples that modified the traditional linear narrative character in the virtuality continuum were video games. Video games conceptual progress and evolution have nowadays generated examples of dynamic and experimental storytelling often with open ends or resolutions. This increases

the range of possibilities for exploration in environments and actions and could be applied besides the mere recreational context.

4.3. *Virtuality continuum: technical and conceptual approaches*

The approach to virtual reality technologies as an ICT has shown their influence in fileds such as education or artistic/creative process. This approach has held a number of important contributions to the field of representation in communication and education science. Virtual reality and immersive environments have a strong expressive power which contributes to open new artistic and creative ways. This expressive power establishes new innovative approaches in putting together components for designing interactions between individuals, information and space.

This will in turn expand the possibilities in new experimental artistic expressions that can find applications in science and technology. In fact, producing emerging expressive conceptual categories and phenomena are part of the theoretical construction of the area that extends from physical space to virtual reality. The virtuality continuum is an ensemble of communication channels where it is necessary to develop new languages, categories and ways of expression. It is also a canvas where drawing new information models to be applied in arts, scientific research or communication is possible, as well as studying in-depth the evolution of language and feedback in STEAM disciplines. Concepts such as «phantasmal media» (Harrell, 2013) serve to partially explain human behaviour and cultural constructs by the growing presence of digital interactive technologies in several fields. Cultural constructions in the era of virtual environments and augmented information have a parallel evolution with technology, where a phenomenon of reciprocity between the arts, science and technology turn facts happening in virtuality continuum into reality: interaction, simulation, immersion, multidirectional communication or research in human-computer interaction, interaction design or user experience.

It's also necessary to taxonomically categorise and classify the components under the aforementioned approach, in which VR, AR and physical space and objects converge. Those hypothetical taxonomical approaches will help us to better visualize, understand the complexity of the interrelation between the real and virtual environments, in a context where ICT are present in our everyday nature.

The possibilities to play, to create, and to interact with peers, as well as the research in different domains, increase in parallel with the development of technological devices. This continuous line (virtuality continuum) allows us to focus on specific features to distribute elements along the virtuality continuum and describe their nature and their possibilities: virtual reality, augmented reality, free hardware, robotics, game engines. The categories will help the researcher study how technologies can be applied to diverse domains, develop analytical methods and apply them to a wide spectrum of fields. For example, the use of game engines enables the development of activities with many constructivist possibilities (in an

educational approach). That also allows the development of new grounds where technologies based on the virtuality continuum approach can be applied. Augmented reality has a relevant impact on areas such as scientific education, cultural heritage studies or interactive activities in museums – an important change in the relationship between the individuals and the physical environment. While decreasing the costs of the devices and enabling the implementation into the learning contexts. This also leads to an innovative relationship between the individuals and their environments, where devices and technologies act as intermediaries.

In this regard, approaches to aforementioned research techniques, both quantitative and qualitative, will help us to define an taxonomically classify factor related with virtual reality, augmented reality or immersive environments.

Results show also the need to improve communicative processes and effectiveness in interaction possibilities. Information and communication technologies are increasingly more interactive. For that reason, it's necessary to define new approaches in areas such as interaction design, user experience or human-computer interaction, in order to design new experiences allowing subjects to be active.

5. Discussion and conclusions: steam and virtuality continuum

Virtual, augmented and mixed realities are an interesting field of research. The consolidation of their application in recent years has proven a great opportunity to study more in-depth the features of interactivity, as well as components such as storytelling, STEAM and virtual/immersive environments. Head-mounted display (HMD) devices have been introduced, tested and implemented in several areas, disciplines and domains in recent years. For that reason, in ICT and human factors there is a growing trend that opens new opportunities for research in those domains. Conceptual frameworks and recent research in domains related with immersive and interactive technologies and human factors show how influential the cultural and technological areas are, and the need to create interdisciplinary approaches. The use, integration and implementation of immersive or interactive technologies (VR or AR) in a wide range of research contexts, reveals an interest of going deeper in exploring and analysing the possibilities of factors such as immersion, simulation or interactivity.

The study of the components gives us also a wide range of possibilities to explore innovative applications in ICT, such as integrated development environments (IDE) or game engines. This knowledge may also improve the design of interactive processes between users, information, technology and environments. Integrating innovative methodological and conceptual approaches in domains such as the education and arts can be done through this new generation of information and communication technologies. As possibilities of interactivity increase with evolution of devices, domain such as arts or education may implement new approaches.

The challenge lies in comparing the methodologies to other domains. Technological progress also needs innovation in methodologies and integration processes. It is also necessary to implement the heuristic approach, as well as the emphasis on the need of exploring the new ways of interaction and gameplay in virtual worlds. Several domains need to focus also in visual or motor features and the limits of the human being, such as language, health sciences, educational sciences, fine and digital arts, collaboration between peers, cultural heritage and museums (spaces of representation) or ergonomics. That is the reason why video games, game engines, augmented reality tools, robotics or transmedia storytelling are innovative tools for research in science, engineering, communication and arts through simulation, interactivity and immersion.

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