Chapter 27
A Historical Review of Immersive Storytelling Technologies:
New Uses of AI, Data Science, qnd User Experience in Virtual Worlds

Hector Puente Bienvenido
Universidad Complutense de Madrid, Spain

Borja Barinaga
Universidad Francisco de Vitoria Madrid, Spain

Jorge Mora-Fernandez
University of California, San Diego, USA

ABSTRACT

This chapter is focused on describing the history and the current relevance of user experience (UX) techniques that combine data science and AI in the research field of interactive and immersive storytelling, including virtual and augmented realities. It initially presents a brief history of interactive storytelling, video games, VR and AR, AI and data science, and the user experience (UX) techniques used in those areas. Later, the chapter describes the UX techniques in depth, using AI and data science that work best and are more useful for testing interactive media products, describing examples of its applications briefly. Finally, the chapter presents conclusions in relationship with utopias and dystopias regarding the future use of UX, AI, and data science in several areas such as edutainment, social media, media arts, and business, among others.

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INTRODUCTION

There has been a significant implementation of technology to manage scientific data during the last two decades. One consequence of the increased use of technology has led to diverse findings in science and high techs like VR systems, UX, and big data analytics, that have challenged and questioned our descriptions and representation of reality and our daily habits.

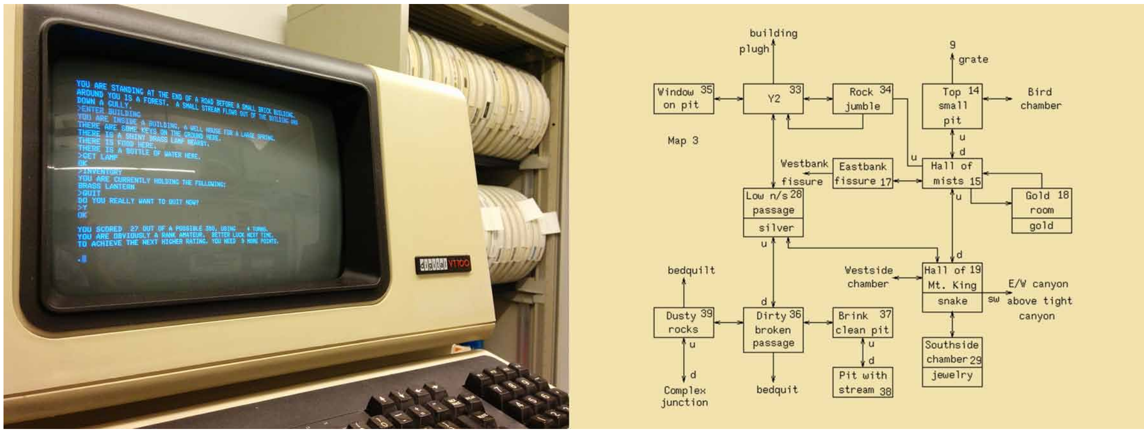
This chapter focuses on the material senses. Significant optimization and economization of virtual reality (VR) and augmented reality (AR) displays have served to question, explore, and research the communication and languages of the material senses to a greater extent so that they can be merged and immersed in different VR and AR products. This new reality has reinforced a more profound recreation of the physical senses. Advancements in applied data science, the increase of bandwidth for data transfer networks, mobile ram abilities and memories, massive media alternatives for displaying and collecting social information, and the implementation of programming systems have helped Artificial Intelligence (AI) to manage significant amounts of personal information. These improvements are mainly motivated by the desire to increase business and industry profits through the registration, analysis, and monetization of the collected data from users and data based on the human interactions with different high-tech interfaces (computer, mobiles, VR and AR displays, and tablets). Of course, we can use high technology for other purposes, such as education or improving human beings' wellness. However, business and industry are still the leitmotivs of most research and applications of data science and artificial intelligence.

In this complex context of massive subjective and objective data and the ability of managing it with artificial intelligence software, companies are investigating the possibility of using data science, which gathers large amounts of subjective experiences, to collect objective responses from their users through the analysis artificial intelligence can provide.

HISTORICAL REVIEW OF INTERACTIVE, IMMERSIVE AND TRANSMEDIA STORYTELLING UX

Automated and interactive narration is usually linked to video games. However, it is not entirely true that its origin is only in computer games. Many of the characteristics of these narrative systems can be found in board games and, significantly, in the birth of role-playing games, invented by Gary Gigax (1938–2008) and Dave Arneson (1947–2009). The game *Dungeons & Dragons* (1974) was revolutionary, for it changed the paradigm of the traditional game. What is more, it established the way to elaborate a free and interactive story, lived in the first person, and based on rules. With the popularization of video game consoles and personal computers, due to the cheapness of electronic components, many young engineers became interested in programming fantasy-themed worlds that were mainly influenced by the work of J.R.R. Tolkien (1892–1973). Another critical factor to emerge was connecting computers in networks, such as through Arpanet (whose development began in the 1970s with the NCP protocol, *Network Control Program*, before the current TCP / IP, Transference Control Protocol and Internet Protocol). It was William Crowther, one of the programmers involved in the development of Arpanet, who programmed the first fully interactive, text-based fantasy story: *Colossal Cave Adventure* (1976) (Figure 1) (Barinaga, 2010). In 1977, the interactive story was polished and expanded by Don Woods, one of the fathers of hacker culture, who, as a student, discovered *Cave Adventure* on a Stanford University computer.

Figure 1. Left: Colossal Cave Adventure (1977) running on a PDP-11/34 and displayed on the VT100 console. Author: Autopilot. Right: a detail of a graph showing the structure of the world from the Colossal Cave Adventure Page (https://rickadams.org/adventure/index.html)



What was revolutionary about the system invented by Crowther was that it performed some very useful simplifications to produce the behavior of a purely artificial world. Colossal Cave Adventure's world has characters, space, and time – the essential elements for any narrative. Crowther conceived a world organized by spaces and connected by paths, much like the galleries of a cave. In each space, the player finds objects or characters, and the player can explore the world by picking up and putting down items (Barinaga, 2014). Notably, *Colossal Cave Adventure* has the fundamental characteristics of an interactive story, as defined by Crawford, which are structure, people, conflict, puzzles, choices, and spectacle (Crawford, 2005).

Significantly, the AI used in this program differed from the conventional one that was linked to the classical game studies, especially the game of chess, based on the research of Claude Shannon (1916–2001), used in emblematic projects like the *IBM Deep Blue* (1996) or *Deepmind/Google Alpha Go* (2015). The AI in the video game is much simpler but more effective from a narrative point of view. The Crowther structure simplifies reality without requiring complex AI and is based on simple state changes and automation. Despite its simplicity, the structure creates a rich experience, offering a great sense of freedom and a complex narrative. *Cave Adventure's* fundamental difference from other video games is that the AI is primarily used to achieve the feeling of spectacle that Crawford mentioned (Crawford, 2005). The program was designed to make the player's experience something memorable. Thus, the intention is not to simulate human decision making, but rather simulate plausible situations that give a sense of reality. Crowther's program proposed the following key aspects to simplify computing:

- Narrow paths and connections between each space or room that are justified by the narrative. This approach maintains the feeling of freedom while drastically limiting the possible options and facilitating programming.
- The appearance of an inventory that allows the taking and leaving elements. The changes of state caused by these interactions in the matrices serve as a trigger and conditioner of the adventure according to the algorithms of the general rules.

- Writing recognition system and narrator simulation. The game was revolutionary for allowing a natural communication between player and program. When the program was not able to interpret an order, it responded narratively using a random system of phrases and a large dose of humor. This forced the player to seek other alternatives to express themselves or perform actions.

As previously described, since the proliferation of role games and the first computers, computational videogames, especially conversational adventure video games, caused the public to gain more interest in interactive narratives. The main goal became discovering how to combine immersive storytelling with different engaging interactive structures and levels of interactivity so the user experiences could improve, and people could feel more engaged in their narrative experiences and game dynamics.

Emergent forms of interactive cinematic arts exploring these subjects in interactive video games (e.g., virtual and augmented reality, among others) were presented for decades in international conferences and festivals all over the world.

Research groups such as the Interactive Cinema at MIT, publications like The Language of New Media by Lev Manovich of the Visual Arts Department and CRCA at UC San Diego, and the interactive documentaries displayed on museums by the Labyrinth Project led by Marsha Kinder at the University of Southern California, inspired interactive media academic programs. That is how the Interactive Digital Media Programs at the University of Southern California, Carnegie Mellon University, and the Georgia Institute of Technologies started. The last one was led by Janet Murray (1997), the author of the book *Hamlet on the Holodeck: The Future of Narrative in Cyberspace* and who two decades later theoretically established the field (Murray, 2012).

In Europe, a significant exhibition and MIT publication entitled *Future Cinema* integrated the best research groups' findings and media artworks under the same roof at the ZKM, Center for Art and Media. The exhibition was curated by Peter Weibel and Jeffrey Shaw in Karlsruhe, Germany. In Spain, the Medialab Madrid was created around 2003 by Karin Ohlenschläger and Luis Rico, at the Centro Cultural Conde Duque. The center encouraged new media artists to research and create in the areas of interactive media and digital storytelling. *Via Intima* (Inside Track) was the first independent interactive transmedia project with an interactive exhibition, online, and interactive DVD. The project was developed at Medialab Madrid by Daktyl4 and led by Jorge Mora-Fernández and Borja Barinaga. Barinaga became one of the designers of the first academic videogame program in Spain. These creative and explorative spaces served as the first spaces for creation and testing of the emergent interactive digital storytelling arts and user experience (UX).

In terms of theoretical pioneers who persisted and consolidated research studies on interactive narratives, Marsha Kinder (1991, 2014), Michael Mateas (2004), Janet Murray (1997, 2012), Marie-Laure Ryan 2001), Lev Manovich (2005, 2001), Steve Anderson (2011), and Henry Jenkins have helped to establish the descriptions of some critical concepts regarding interactive storytelling and digital media. These concepts include, immersion, agency, and later transmedia. In Spain, in the area of interactive museums, Isidro Moreno (2002) from the Universidad Complutense de Madrid, director of the research group Museum I+D+C, has been an important pioneer. He is the author of the Interactive Museum of the Book of the Spanish National Library and author of the book *Musas y Nuevas Tecnologías*. Following Moreno's investigation lines, Jorge Mora-Fernandez, while researching with some of the mentioned American researchers at UCSD and USC, developed a model of analysis of interfaces to determine the most meaningful variables of interactive and transmedia narratives to study under UX to generate more interactivity, agency, and immersion. These models later evolved into a model of analysis for transmedia projects. In terms of the interactive and new forms of the book, the last years have been relevant to see the formation of the UNESCO New Forms of the Book, chaired by Alexis Weedon, UK, and the research developed by Deglaucy Jorge Teixeira, in Brazil, as well as the international conferences in digital storytelling, ICIDS.

Regarding the digital culture evolution from interactive media storytelling to transmedia storytelling, Marsha Kinder initially used the transmedia concept (1991, 2014) referring to transmedia intertextuality. However, Henry Jenkins is the one who popularized the transmedia narrative term. Jenkins (2011) gave the following description of the term in his blog: "transmedia storytelling represents a process where integral elements of a fiction get dispersed systematically across multiple delivery channels for the purpose of creating a unified and coordinated entertainment experience. Ideally, each medium makes its own unique contribution to the unfolding of the story."

Previously, Jenkins had described in his book, *Convergence Culture* (2006), the concept of convergence as a paradigm for thinking about the present moment of the media change. He defined the change by the stratification, diversification, and interconnection of the media in a converged way that influences the decisions of media producers, politicians, and citizens on the production and consumption of the digital culture. More recently, and because of the latest communicative and cultural practices, Jenkins evolved the convergence concept to become the transmedia term (2011):

Transmedia, used by itself, simply means "across media." Transmedia, at this level, is one way of talking about convergence as a set of cultural practices. We might also think about transmedia branding, transmedia performance, transmedia ritual, transmedia play, transmedia activism, and transmedia spectacle, as other logics.

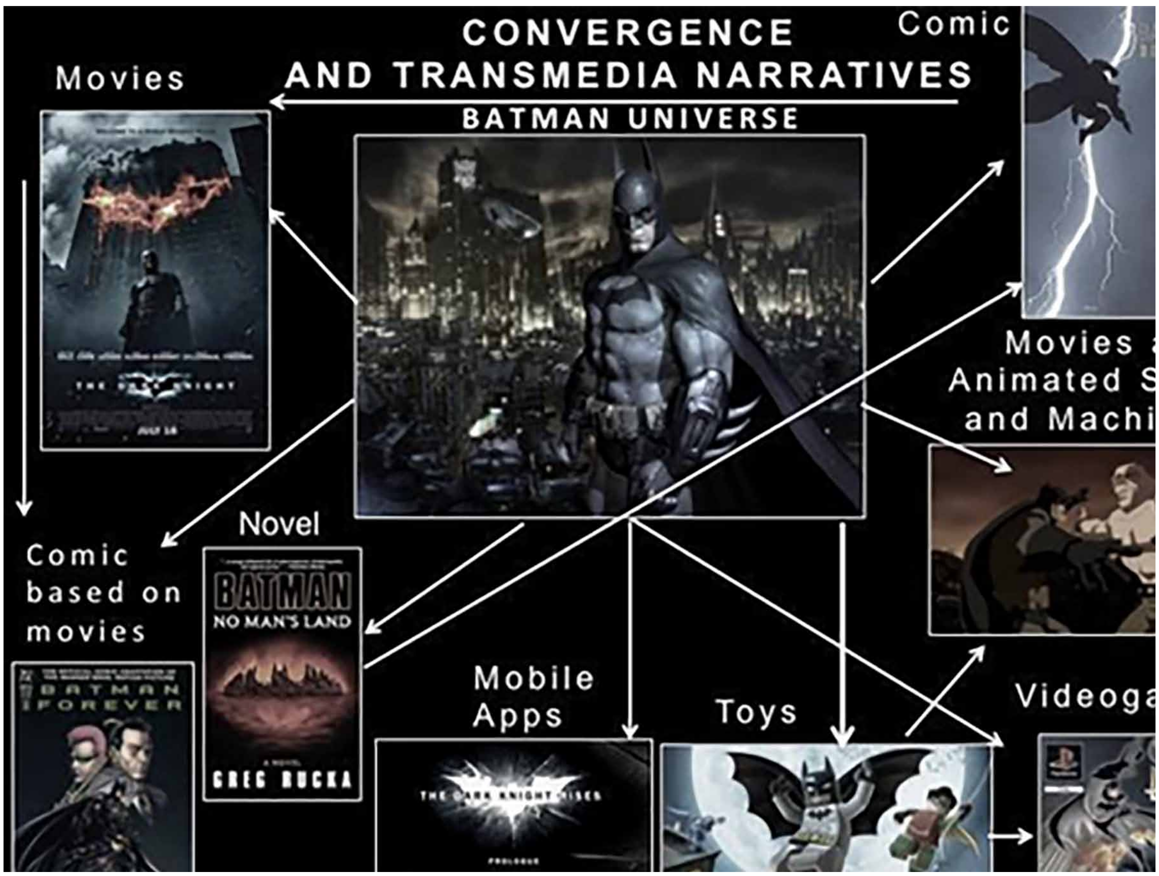
In this regard, the transmedia narrative generates a universe of linear and circular possibilities where the stories start and finish with feedback to themselves and experimented one at a time. The linearity of the interactivity in this regard is understood as the coherent, communicative, immersive, and multilevel flow: aesthetic, narrative, and emotional,

Mora-Fernández (2013). Interactive linearity is a concept that has been developed in detail through time after the digital narrative and cultural evolution from hypermedia interactive narratives Mora-Fernández (2009). See Table 1 for the variables included on the model of analysis to interactive transmedia narratives Mora-Fernández (2019a, 2019b). See Figure 2 for the story flow across-media.

AI and Data Science Use in UX Interactive, Immersive, and Transmedia Storytelling

During the last years, conferences in interactive digital storytelling have been proliferating. An example of these conferences includes the International Conference on Interactive Digital Storytelling (ICIDS). At these events interactive digital storytellers in the areas of cinematic arts, videogames, and virtual reality exchange their project experiences of experimenting with interactive and transmedia digital storytelling systems. Some notable collections and research projects in this interdisciplinary arena are by Nunes, Oakley, and Nisi (2017); Marcus and Rosenzweig (2020); Nack ad Gordon (2016); Schoenau-Fog et al. (2015); Long (2000); Barbic et al. (2017); Mora-Fernandez (2019a, 2019b); Ioannidou (2013); and Parody (2011).

Figure 2. This image visually summarizes the influence and complementary story between media in one of Batman's Universes (from comic, to movie, to animation, to games to book)



It is essential to say that the integration of aesthetic and narrative variables on a human-computer interface is so vast, almost as vast as the human imagination, that some AI used on UX only focuses on very specific aspects, as in shown the next chapters. Therefore, it is presented here as a model that has taken into consideration all the data science needed to perform fundamental research on interactive storytelling. Among others, the most meaningful aesthetic and narrative variables to observe in order to implement the interface product qualities in interactivity, immersion, and agency have been taken into consideration (see Table 1). It is interesting to see how Unity is allowing us to observe more variables for dynamic design adjustment (DDA) purposes. Soon, AI will collect all this data and compare the results between the interactive digital storytelling variables to finally respond to the fundamental question that motivates any UX test in any interactive media product: What are the most effective and attractive aesthetic? And what are the most compelling narrative elements in the interface that motivate and interact in different ways?

Because of the massive number of variables, the UX in interactive digital storytelling (IDS), UX data science, and AI is very simplified. Most of the time the IDS UX tests rely on traditional user experience questionnaires, such as the one used in the research *Connecting the Dots: Quantifying the Narrative Experience in Interactive Media* by Hannesson et al., Schoenau-Fog et al. (Eds.) (2015). However, some

Table 1. Model for analysis of hypermedia interfaces to observe and register the contained aesthetics, narrative elements, type of interactions and ethical values (adapted from Mora-Fernández, 2012)

1. Name and description of the interfaces and the conjunction of hypermedia expressions 1.1. Identifiable denomination of the hypermedia interface. Each different interface that appears on the hypermedia product should be numbered, named and observed under this descriptive model to obtain a deep analysis 2. General characteristics of the interface and detailed description of the multimedia characteristics of the expressions that can allow interaction with any of the narrative elements 2.1. Software: Group of expressions and technological tools that are used for the relationship and generation of natural and virtual interactions A) Of iconic intermediation B) Symbolic C) Combination of A & B D) Natural mimetic • Opened or virtual reality • Semi-opened or simulators of virtual reality F) Convergent G) Pull or push interfaces H) Static or dynamic Interfaces I) Mute or sound interfaces J) Smart interfaces K) The iteration 2.2. Types of image or perceptive representations A) Still image 1) Photo-mimetic 2) Photo-infographic 3) Info graphic B) Still image with sounded image C) Image in movement 1) Cine-mimetic 2) Cine-infographic 3) Cine-mimetic and infographic D) Visual image in movement with or without sounded image E) Audiovisual image F) Sounded image G) Sounded image with or without visual image or extraterritorial images 2.3. Hardware: Group of physical expressions A) Of intermediation B) Natural-mimetic 2.4. Typographic description • Size of letter • Style of font or type • Characteristics or effects of the letter • Color of the letter 2.5. Iconic description 2.6. Symbolic description 3. Features of the characters represented on the interface and general description of the potential interactions with the characters 3.1. Character or avatar of 1st, 2d or 3rd Person	3.2. Physical characteristics • Sex • Age • Height and weight • Hair, eyes and skin colors • Pose • Corporal appearance and customs • Morphological defects • Hereditary aspects 3.3. Sociological characteristics • Economic status • Employment • Type of education • Life and family relationships • Religion • Race, nationality • Function in his community • Political tendencies 3.4. Psychological characteristics • Sexual and moral life • Personal ambitions and motivations • Frustrations, main conflicts • Temper: angry, tolerant, pessimistic, optimistic, etc. • Vital attitude: complacent, combative, surrendered • Insecurities: obsessions, inhibitions, superstitions • Extroverted, introverted, well balanced • Capacities, aptitudes, languages • Qualities: imagination, criteria, taste, equilibrium • Intellectual coefficient: high, regular, low 4. Interactional aspects of the character and type of interaction available: selective, transformative or constructive 5. Values or spiritual principles and unscrupulous values that available to activate through the interaction with the narrative characteristics of the characters. Values and unscrupulous values that appear potentially related with the interaction developed 5.1. Ethical values 5.2. Unscrupulous values 6. Characteristics of the actions represented on the interface and general description of the potential interactions with the actions 6.1. Type of structure 6.2. Secondary theme or subplot 6.3. Changing hierarchy 6.4. Changing hierarchy •Relationships between main and secondary actions •Real relationships between main actions •Real relationships between secondary actions •Simulated relationships between main and secondary actions •Annulated between main and secondary actions 7. Aspects of the interactional actions and type of interaction available: selective, transformative or constructive	8. Values or spiritual principles and unscrupulous values that available to activate through the interaction with the narrative characteristics of the actions. Values and unscrupulous values that appear potentially related with the interaction developed 8.1. Ethical values 8.2. Unscrupulous values 9.Characterists of the spaces represented on the interface and general description of the potential interactions with the spaces 9.1. Natural, constructed, mimetic-natural or mimetic-info graphic 9.2. Senses implied in the spatial perception: view, ear and/or touch 9.3. Implicit space and/or explicit 9.4. 2D/3D or 4D space 9.5. Perspective: size, scale, position and point of views 9.6. Focus or defocus 9.7. Illumination and color temperature 9.8. Props 9.9. Protagonist space and/or hyperspace 9.10. Absent space or suggested space 9.11. Selection space with representation: coincident or different 9.12. Hyperspace 10. Aspects of the interactional spaces and type of interaction available: selective, transformative or constructive 11. Values or spiritual principles and unscrupulous values that available to activate through the interaction with the narrative characteristics of the spaces. Values and unscrupulous values that appear potentially related with the interaction developed 11.1. Ethical values 11.2. Unscrupulous values 12. Characteristics of the time represented in the interface and general description of the potential interactions with the time 12.1. Order: flashback, flashforward, meta-retrospective or meta-prospective 12.2. Duration: pure diegesis, impure diegesis, open or close 12.3. Frequency: repetitive sequence or singular multiple 12.4. Temporal localization: past, present, future, changing or inexistent 12.5. Iteration 13. Aspects of the interactional times and type of interaction available: selective, transformative or constructive 14. Values or spiritual principles and unscrupulous values that available to activate through the interaction with the narrative characteristics of the times. Values and unscrupulous values that appear potentially related with the interaction developed 14.1. Ethical values 14.2. Unscrupulous values

projects developed and programmed their tools to complement the user experience questionnaires. Some interesting ones found on Nunes, Oakley, and Nisi (2017), and Schoenau-Fog et al. (Eds.) (2015) are:

- Centre for Game by Aamri and Greuter, Schoenau-Fog et al. (Eds.) (2015).
- *Mise-en-scène: Playful Interactive Mechanics to Enhance Children's Digital Books,* Design Research, RMIT University, Melbourne, Australia. This research uses "two instruments Reading Motivation Scale (IRMS), and direct observations during the three school reading sessions… ...The *Motivation for Reading Questionnaire* (MRQ) was designed by Wigfield and Guthrie, and it measures 11 dimensions, including reading efficacy, challenge, curiosity, reading involvement, importance, recognition, grades, social competition, compliance, and reading work avoidance."
- *Connecting the Dots: Quantifying the Narrative Experience in Interactive Media Story Immersion in a Gesture-Based Audio-Only Game* by Wu and Rank, Schoenau-Fog et al. (Eds.) (2015), from Drexel University, Philadelphia, PA, USA. The researchers used an audio-based UX. They "compare useful designs of audio feedback that are responsive to hand gestures to both encourage user participation and maintain immersion in gesture-controlled audio-only environments. For the experimental study, two designs for responsive audio feedback were implemented in two game versions, as described below. We set up a between-subjects experimental design in order to compare the two game versions and their effect on the evaluation of the game, including its immersive qualities (…). The method is based on three moments: Experiment setup: hand motion input, processing, and audio output. The hardware setup for the game includes using a Leap Motion Controller for hand tracking and data input, a laptop for data recognition and processing of the game, and noise-cancelling stereo headphones for audio output."

- *Generating Side Quests from Building Blocks* by Tomas Hromada, Martin Cerny (B), Michal Bıda, and Cyril Brom, Schoenau-Fog et al. (Eds.) (2015) from the Department of Software and Computer Science Education, Charles University in Prague, Prague, Czech Republic. Their research developed "multiple automated quests generating systems were described in the literature. The GrailGM system uses a forward chaining inference engine to recombine quest elements given by a designer to form quests with multiple solutions and to guide the player's progression through the game. Petri Nets have also been proposed as models for generating quests. One of our primary goals was to keep the system simple and controllable while expanding the expressive power of template-based systems. To achieve both, we decided to split quests into blocks. Each block represents a short section of a quest (e.g., killing a monster to obtain an item). The blocks are arranged into a directed acyclic graph (DAG) where edges connect each block to its possible successors. The DAG may be represented explicitly (as in our implementation) or given implicitly by conditions. Blocks that have no incoming edges are called start blocks, and those with no outgoing edges are end blocks."
- *Evaluation of Yasmine's Adventures: Exploring the Socio-Cultural Potential of Location Aware Multimedia Stories* by Dionisio, Barreto, Nisi, Nunes, Hanna, Herlo, and Schubert, from Madeira-ITI, University of Madeira, and the Design Research Lab, Berlin University of the Art, Berlin N. Nunes et al. (2017). Their research entitled. In the research there is a combination of using Nvivo software. "The questionnaire and interview data were then analyzed using a grounded theory affinity analysis with the Nvivo software tools support. Researchers conducted a bottom-up data analysis reviewing and iterative process in three stages: open coding (quotes and high-level categories), affinity diagrams (relationships between categories), and theme organization (most frequent themes and description)."

In terms of interactive digital storytelling using a collection of specific data in combination with AI in UX AI Mobile and VR narrative experiences, some interesting examples appeared in *Interactive Storytelling* (Nunes et al., 2017):

- Developed by Kampa and its research Authoring Concepts and Tools for Interactive Digital Storytelling in the Field of Mobile Augmented Reality, from Hochschule RheinMain, Wiesbaden, Germany SPIRIT appears like an exciting UX tool. "In SPIRIT, a Storytelling XML (STARML) dialect has been derived from ARML by adding authoring-friendly XML-tags, with the focus on location-based content description for IDS. Further, a plot engine has been developed that interprets the STARML content structure, processes user interactions, and triggers AR video and other media. This engine uses conditions for planning. Authoring AR content has been made accessible for programmers by systems like EDoS and ComposAR. For non-programmers, TaleBlazer offers a visual script language like Scratch. An authoring concept is observing the authors for authoring tool development (...). The SPIRIT authoring tool StoryPlaceAR was developed out of the need to author media content outdoors in an ad-hoc manner (…). The system "immersive authoring for tangible AR" transforms 'What You See Is What You Get' authoring concept into 'What You Feel Is What You Get'. VideoTestAR enables prototypical AR video production and automatically authors the STARML content structure for immediate experience testing. In authoring for IDS, after content creation, the story structure can be altered by filling in content into an existing story structure. For this, several working steps are performed on the same STARML file and folder system. This process creates a bottleneck of collaboration and communication in an interdisciplinary team. In conclusion, this bottleneck exists for the authoring of XML structures for IDS systems."
- Developed by Bala, Nisi, and Nunes in their research Evaluating User Experience in 360o Storytelling Through Analytics at Madeira-ITI, University of Madeira, they developed their evaluation VR analytics for narrative structures "Based on the need for evaluation of complex narrative structures in VR storytelling, we designed IVRUX, a VR analytics platform for 360o video. This tool, intended to be used in an academic context, offers a support system to facilitate communication of creators and/or researchers with participants. The system is composed of three components: an online dashboard for researchers (built using the Angular framework) and a mobile VR application for the participants (built using Unity), connected through a REST API backend (Node.js and MongoDB). The system is designed so that the researcher does not need to have any expert skills (e.g., coding) to evaluate content."

In conclusion, IDS UX testing that can provide useful information for data science and AI, but there is a long way to go. However, software by iMotions, which integrates eye-tracking, EEG, and emotional facial recognition, has emerged as a promising tool for interactive communications and storytelling research. Some exciting applications of interactive storytelling on recovery from addictions can be found in research by Mora-Fernandez et al. (2020) entitled *iMotions' Automatic Facial Recognition & Text-Based Content Analysis of Basic Emotions & Empathy in the Application of the Interactive Neurocommunicative Technique LNCBT* (Line & Numbered Concordant Basic Text).

Figure 3. The video game Pong (Atari, 1972) is a perfect example of UX principles with very limited technological possibilities. This game put Atari at the forefront of the new entertainment industry. Exhibition in the Tekniska Museet, Stockholm, Sweden (16 September 2014). Photography by Diderot

BRIEF HISTORY OF UX APPLIED TO VIDEOGAMES

The design systems used in video games undergo constant optimization and evolution towards a fully adaptive user experience. They are applied both in the gaming medium and transferred to the most varied experiences by hybridizing the digital and physical world (Sequeiros & Puente, 2018, 2019). The innovations in design systems respond to a growing audience's demands. Therefore, one made up of people with unique characteristics, such as desires and interactions. Video games as cultural devices have been adapted to users through tools that allow the monitoring and analyzing of a player's performance or preference, enabling designers to adjust and tune the user's experience (Puente & Sequeiros, 2019a, 2019b). Dynamic design adjustment (DDA) not only allows the game to be altered in real-time based on the decisions and behavior of the player, but it also enhances the enjoyment and social inclusion of the game without neglecting the capacities and possible limitations of the users. DDA thereby follows the design justice approach (Crews & Zavotka, 2006; Constanza-Chock, 2020).

Traditionally a closed medium with predetermined systems, video games and their social contexts have been intertwined and merged with today's reality. Although past attempts, such as *Tempest* (Atari, 1981) and *God Hand* (Clover Studio, 2006), were limited by technology, a design approach that allows the game experience to be adapted to the player's interests has emerged. As it has been demonstrated, usability is a critical element in interactive systems (Maguire, 2001). For example, Missura and Gärtner (2009) have emphasized that the ideal video game should adapt its difficulty dynamically based on the player's performance.

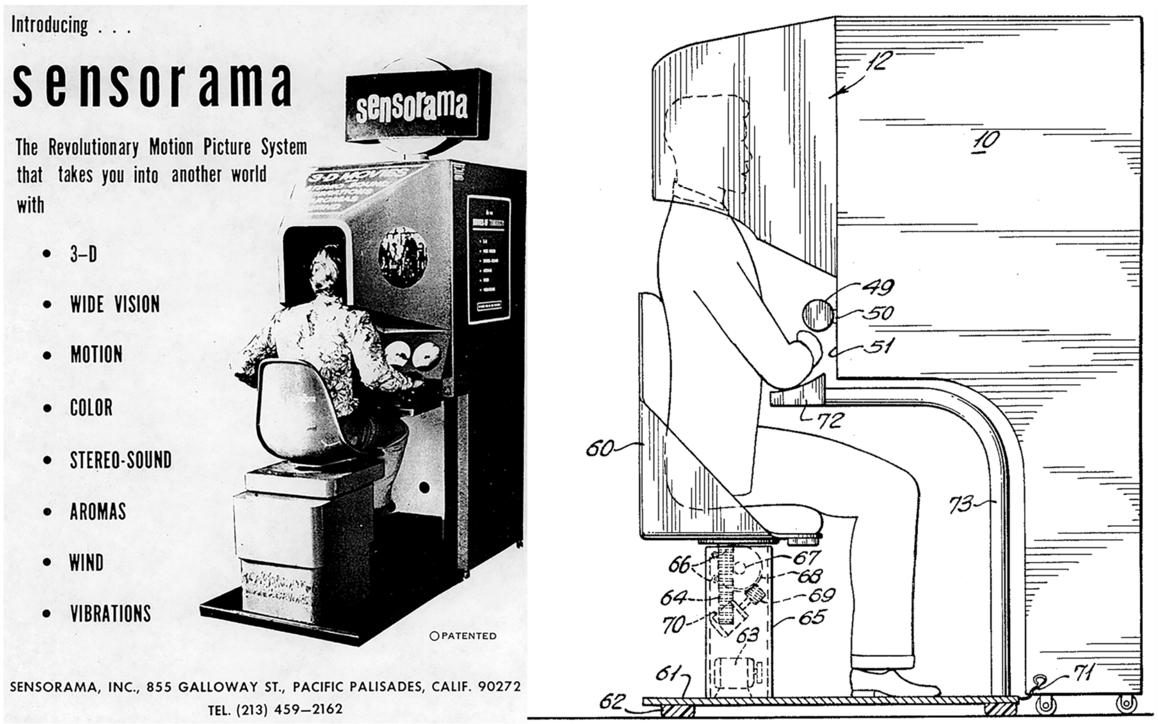
From its origins, the field of videogames has been a cutting-edge platform for UX studies. Interfaces, gameplay, and narrative maintain, in most cases, a critical dependency to improve the player experience. After the burst of the first video game consoles into homes, such as Ralph Baer's *Odyssey* (Magnavox, 1972), the personal computers' current architecture was established: a motherboard, a sound card, and a graphics card. From that moment on, the interface development related to image and sound materialized in revolutionary projects such as the human-computer interfaces for the *Apple Lisa* (Mackintosh 1983), linked to Steve Wozniak and Steve Jobs (1955–2011) who were both ex-collaborators from Atari. (Kent, 2001)

In the eighties, Atari did not know what kind of industry it was creating. However, they did know the importance of narrative immersion and the experience of the players in their games. This is the reason they created research and development departments that thought about the future of interfaces and new options for human-computer interaction as a key to success (Kent, 2001). Today, some of these historical interfaces are part of the collections of prestigious museums, as is the case of *Pong* (1972; Figure 3), which is in the MOMA and the Science Museum of London, among others.

Unlike other fields, in the video game industry the importance of UX is preponderant. Games are based on the player's experience, and the activity is not compulsory but voluntary. If the experience is not rich and exciting, and the mechanics, gameplay, and narrative are not in line with the interface's quality, the player will stop playing, and the product will be a failure (Schell, 2008).

In this sense, from the origins of the main mechanics, it can be said that a massive incursion of artificial intelligence in the development of video games and in the improvement of the UX has been experienced, highlighting three key aspects:

Figure 4. Sensorama advertising poster and illustration of Morton Heilig's Sensorama device, a precursor to later virtual reality systems (Filed Jan 10, 1961). Author: Morton Heilig. Figure 5 of U.S. Patent #3050870 (via https://patft.uspto.gov/)



- With the increase in complexity of video games, automated and intelligent help and management systems have emerged that improve the quality of the gameplay and minimize the importance of secondary tasks not related to the experience or gameplay (Millington, 2006).
- Data analysis and information flow methods have been improved to facilitate testing and design, even from the game engines themselves.
- Increases in processing speed allows for the management of the intelligent automatic behaviors of a significantly greater number of non-player characters at the same point of the game. (Millington, 2006)

MOST RELEVANT MILESTONES IN VR, AND AR USER EXPERIENCE

Virtual reality has more than fifty years of existence now. However, in the last few years VR technology and industrial uses have been growing dramatically. The advances in electronics, energy (more efficient batteries), and computer technology have made it possible to realize a dream that began to develop from the multi-sensory simulator *Sensorama* (1960), created by Morton Heilig (Figure 4).

Sometimes the concept of VR is fuzzy, due to the large number of uses in the context of virtual spaces generated by 3D computer technology. Nevertheless, VR is mainly related to the simulation of a space by computer graphics to allow the user, intermediated through a hardware interface, to interact

Figure 5. HTC Vive (2016) vs VPL Research DataSuit (Circa 1989). HTC Executive Director of Marketing Jeff Gattis wears the HTC RE Vive (3 March 2015). Author: Maurizio Pesce. VPL Research DataSuit, a full-body outfit with sensors for measuring the movement of arms, legs, and trunk developed circa 1989. Displayed at the Nissho Iwai showroom in Tokyo (4 October 1999). Author: Dave Pape

with things in a similar way that he or she would in the real world. The VR experience is immersive by definition and tries to be multi-sensory. (Fuch, 1992; Gigante, 1993).

The first head-mounted display (HMD) of VR was *The Sword of Damocles*, constructed by Ivan Sutherland (Sutherland, 1965). The system was able to track the orientation of the head to update the virtual scenario.

In the seventies there were relevant systems with multiple uses, such as the *GROPE* (1971). This was a human-force-feedback developed at the University of North Carolina. Today, this type of system combined with our advances in data transference could allow, for example, doctors to practice surgery remotely, systems like the *Da Vinci Surgical System* (Intuitive Surgical, 2000), present in approximately five thousand hospitals in 2020 (Singer 2010). Another early VR invention was *VIDEOPLACE* (1975) by Myron Krueger (Krueger et al., 1985). This hardware was the origin of all the movement reconnaissance systems used in later video game hardware, like *Microsoft Kinect* (2010) and *Nintendo Wii* (2006).

In the eighties, new interests were found in the military field for the use of virtual spaces. In 1981, Atari collaborated with the US Army to develop a training simulator for the gunners of the M2 Bradley Tank, inspired by the successful arcade game *Battlezone* (1981; Barinaga 2016). In 1982, the US Air Force, with the Armstrong Medical Research Laboratories, developed the *VCASS* (Visually Coupled Airborne System Simulator), an HMD system to control the pathways of missiles and targets (Mazuryk & Gervautz, 1999).

In the mid-eighties, the first VR commercial devices appeared. Examples include the *Fake Space Labs BOOM* (Binocular-Omni-Orientational Monitor, 1989) and the *HMD Data Glove* (1985) by the VPL company (Figure 5).

But in the end, all these devices, and the advances made in the 1990s, were too costly and bulky to reach the entertainment industry. Moreover, they remained as anecdotic, military, or scientific experiments with expensive hardware. In 2016, two companies launched to the market affordable and compatible new VR glasses systems: the *HTC Vive* (HTC) (Figure 5) and the Oculus Rift (Oculus VR). The videogame industry has embraced this technology as an up-and-coming field for the new generation of games. Furthermore, VR glasses have started to become a convenient interface for design and 3D modeling.

Although augmented reality shares similarities with VR, it is a visualization of reality with virtual content that augments the standard visual information. Thus, it enriches rather than replaces the real world (Bryson, 1992).

In 1990, Tom Caudell coined the concept of *Augmented Reality* while working on a project to simplify the view of wire schematics for airplanes at the Boeing company, and he developed with his colleague, David Mizell, the idea for special glasses that show information in real-time (Carmigniani et al., 2011). However, the advances in AR remained in a scientific or military context until 1999. The technology became more accessible when Nara Institute of Science and Technology's Hirokazu Kato released the *ARToolKit*, an open-source tool kit for any OS platform to capture video and insert, in real-time, virtual information. Since the AR modules are present in the OS of smartphones, the uses of the technology have been exponentially growing. In 2013, Google launched the *Google Lens*, and in 2016 Microsoft developed the *Holo Lens* for Windows Mixed Reality. Nintendo revolutionized the game industry with the AR game *Pokémon GO* (2016; Figure 6). Today, AR content can be viewed with smartphones and is used habitually in commercials, sports, and video games.

Increasing amounts of research using AI and data science in AI and VR have been developed during the last years. Some exciting publications that have collected interesting research are Jung and Tom Dieck (2018), Peddie (2017), as well as some proceedings from the EuroVR International Conference, Barbic et al. (2017), among others.

AI AND DATA SCIENCE IN STORYTELLING AND VIDEO GAME DESIGN

Artificial intelligence and data science have been linked to the development of commercial video games since their origins. Character simulation, non-player character (NPC) movements and actions, algorithms, and predictability, among others, play a fundamental role in gameplay experiences (Bekkes et al, 2012; Nantes et al, 2008) (data science applications are especially visible in areas like serious games).

The first game to partially use an AI dates back to the 1950s. This is the case with Nim. His AI implemented combinatorial game theory using binary logic operations. Two decades later, games such as *Pong* (1972), *Space Invaders* (1978), and *Galaxian* (1979) would already include simple AIs that incorporated preset patterns based on examining the input (action) of the human user. A few years later *Tempest* (1981) appeared. It was the first video game to use player performance parameters to optimize their gaming experience and achieve a balanced level of challenge. Thus, data science applied to video games was born and would revolutionize the field of game balancing adjustment with optimized matchmaking, generation of rewards, and item-drop mechanics.

Today, dynamic design adjustment (DDA) has been proven successful in various media such as video games and interactive experiences (Maguire, 2001). Significantly, DDA has been shown to improve the performance and the engagement of the users (Andrade et al., 2006; Xue et al., 2017). Adjusting NPCs' behavior to make them less aggressive, adapting the number of enemies in an environment and their health or damage values, and increasing the recovery speed of the health bar of players are some alternatives and design decisions that have been applied in studies (Chapman & Hunicke, 2004). DDA has also been as applied to favor the user experience in matchmaking (Aghdaie et al., 2007). However, the use of dynamic design adjustment is not limited to mechanics. The narrative can also be altered by adapting the narration to the player's profile. Graphics engines like Unity already have their own tool to implement dynamic design and make this data more accessible for development studios.

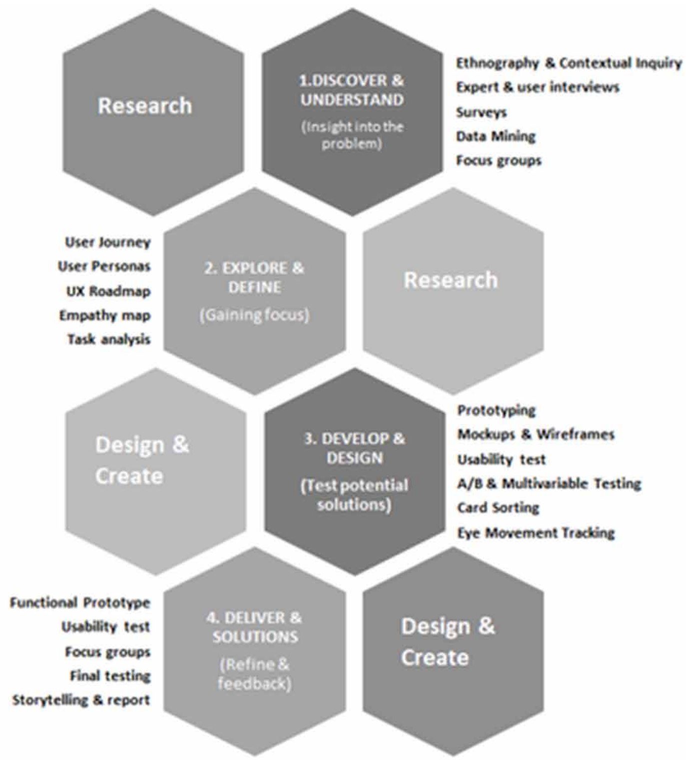
Figure 6. Pokémon GO fever in Japan (12 October 2019)

Corporations also have DDA systems based on machine learning. This is the case with IBM Watson. Through algorithms, Watson undergoes constant learning and adaptation, allowing for the development of unique systems for each player and individualization of the user's experience.

This approach opposes the traditional vision of the video game as a fixed and pre-designed experience without adaptive measures to the behavior and interest of the player. The traditional structure of videogames can be observed in the GDDs (*Game Design Document*) of different video games, such as *Prince of Persia* (Broderbund, 1993), *Grim Fandango* (Lucas Arts, 1998) and *Planescape: Torment* (Black Isle Studios, 2009).

The main point is not only located on the adaptation of video games to the player, but on how this interaction is carried out. With Niantic and its video game *Pokémon GO* (2016) (Figure 6) as the maximum exponent, the trends of video games have been observed to leave the digital medium and merge with reality. Pervasive video games have been integrated, taking the mechanisms and dynamics of prior and 'classical' games to other formats such as AR. The augmented reality format is acquiring new titles, such as *Five Nights at Freddy's AR: Special Delivery* (Illumix, 2019), *Shin Megami Tensei Liberation Dx2* (Atlus & Sega, 2018), and the currently in development *The Witcher: Monster Slayer* (Spokko, TBA). There is an interest in developing and improving AR-based experiences.

Figure 7. Different UX techniques that are being used in the design of immersive experiences and services shown as steps (inspired by Design Council's Double Diamond)



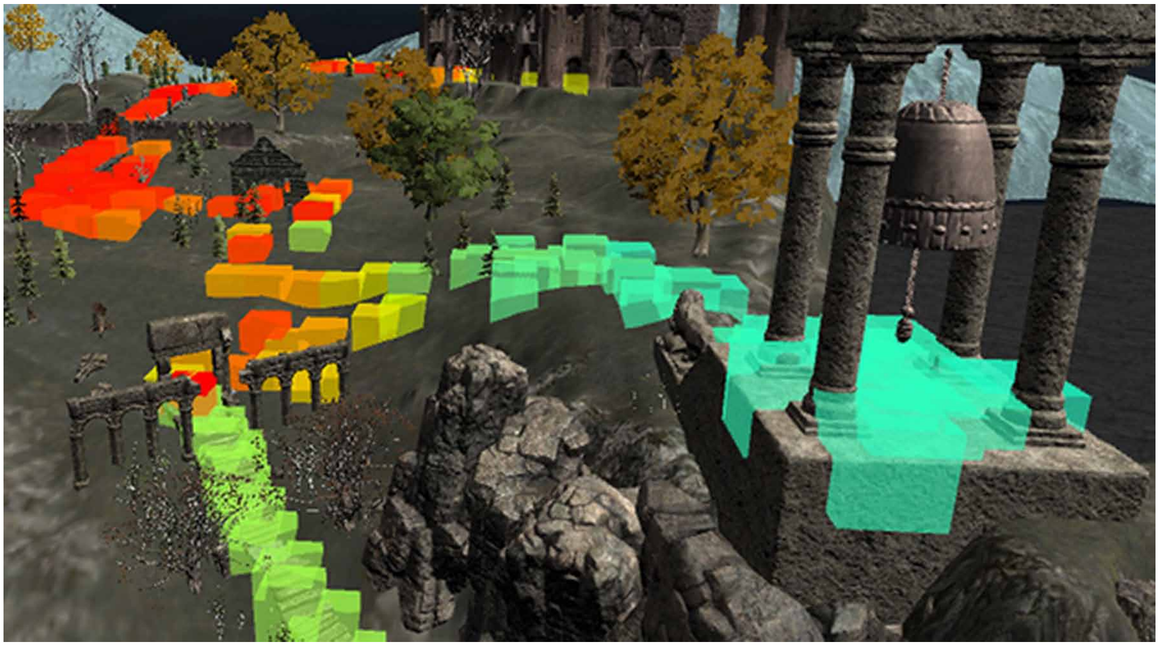
Storytelling and gaming systems based on data science and AI have permeated their environment (Mateas, 2003). We can currently observe multiple gamified and data-driven experiences in museum tours, digital narratives, and dating apps. For instance, the Prado Museum in Madrid has an interactive room (room number 39) where VR is used to interact with art pieces, which again demonstrates the importance of this new technology.

Thus, data science and artificial intelligence are critical pieces in the search for memorable experiences that consist of living an experience rather than consuming a product or story. The aforementioned methods are progressively approaching an increasingly immersive experience based on data analysis, which could be called Peak Immersive Experience. Using embedded metrics in devices, such as AR or VR, video game designers are encouraged to take advantage of the hardware paradigm change and establish DDA as a must-have from now on.

METHODOLOGIES TO IMPLEMENT UX INTERACTIVE AND IMMERSIVE STORYTELLING VR AND AR

After observing the great field that data science and artificial intelligence have to cover, this chapter focuses on using AI and applied data science in user experience techniques.

Figure 8. Unity Analytics heatmap (showing players' areas of interaction)
Source: Unity Analytics Documentation, 2021



First, a mapping of the different UX techniques (organized in design phases) that are currently being applied in the field of media storytelling must be explored.

Figure 7 identifies the different UX techniques that are being used in the design of immersive experiences and services. Inspired by the Design Council's Double Diamond, we have carried out an analysis of the research techniques most commonly used in the different phases of the design process. Notable is how an increasing influence of AI and applied data science in user experience techniques can be observed.

In this progressive integration of UX, AI, and data science, differentiation can be made between two relevant types of processes in terms of design systems and methodologies.

1. How do AI and data science collect information?
2. What narrative and aesthetic variables are currently considered most relevant or significant?

Although there are numerous examples of data analytics and tracking algorithms used in audiovisual devices, the current trend is to take advantage of the information collection options integrated into the development engines themselves (such as Unity or Unreal).

Any pattern of play, behavior, event, or interaction is recorded in a database, which can now be handled very intuitively via a data dashboard. This ability allows to collect and cross all the information on variables of interest for our analysis.

The narrative and aesthetic variables that are currently considered the most relevant or significant are the following: visual and special effects, generation of emotions (Fernández et al., 2021), quality in level design, and story (cutscenes, narrative interactions, etc.).

- quality, diversity, and customization of avatars,
- number of interactions (by click or collision) with game objects,
- level of concentration, emotions (very relevant in sensory storytelling) and attention on environment and user interface design elements (measured through biometrics, interactions and heat maps; see Figure 8),
- percentage of space to map explored (including percentage of completion or secrets discovered),
- the possibility of "skipping" or avoiding the story (cutscenes, textboxes) in narrative experiences (variables of great interest are the total and relative time of reading and listening to the story, the percentage of scrolling made to the textboxes, the number of skips performed, the number of interactions with other non-player characters),
- relative weight of the narrative (in time and relevance) on the gameplay and game experience (measured by game test and questionnaire, engine tracking events, etc.) and
- multidimensional measure of creativity (Jackson et al., 2012).

Engines like Unity already have their own tool to implement dynamic design and make it more accessible for development studios. Thus, GameTune and Unity Analytics are positioned as a dissociative element of DDA and high-budget video games, as Unity is one of the most used engines for video game development. The more variables that can be identified and contracted, the closer developers will be to having a complete map of what works and what does not in UX applied to interactive media storytelling.

IMPLEMENTING USERS' INTERACTIONS AND IMMERSIVE EXPERIENCES IN DIGITAL STORYTELLING

Reflections of What Works and What Does Not

The progressive rise of digital mediations and UX design techniques has led to a productive orientation that finds in the creation and sale of immersive and designed experiences an important niche of commercial, socio-cultural, and political exploitation. In this sense, authors such as Pine and Gilmore (2011) describe the emergence of a new type of economy that began at the end of the 20th century and is based on the production of highly personalized interactive experiences and digital storytelling. Producing memorable and captivating experiences to be sold and enjoyed is a trend that has always been latent, particularly in the entertainment field, but in recent decades this trend has exploded and grown significantly.

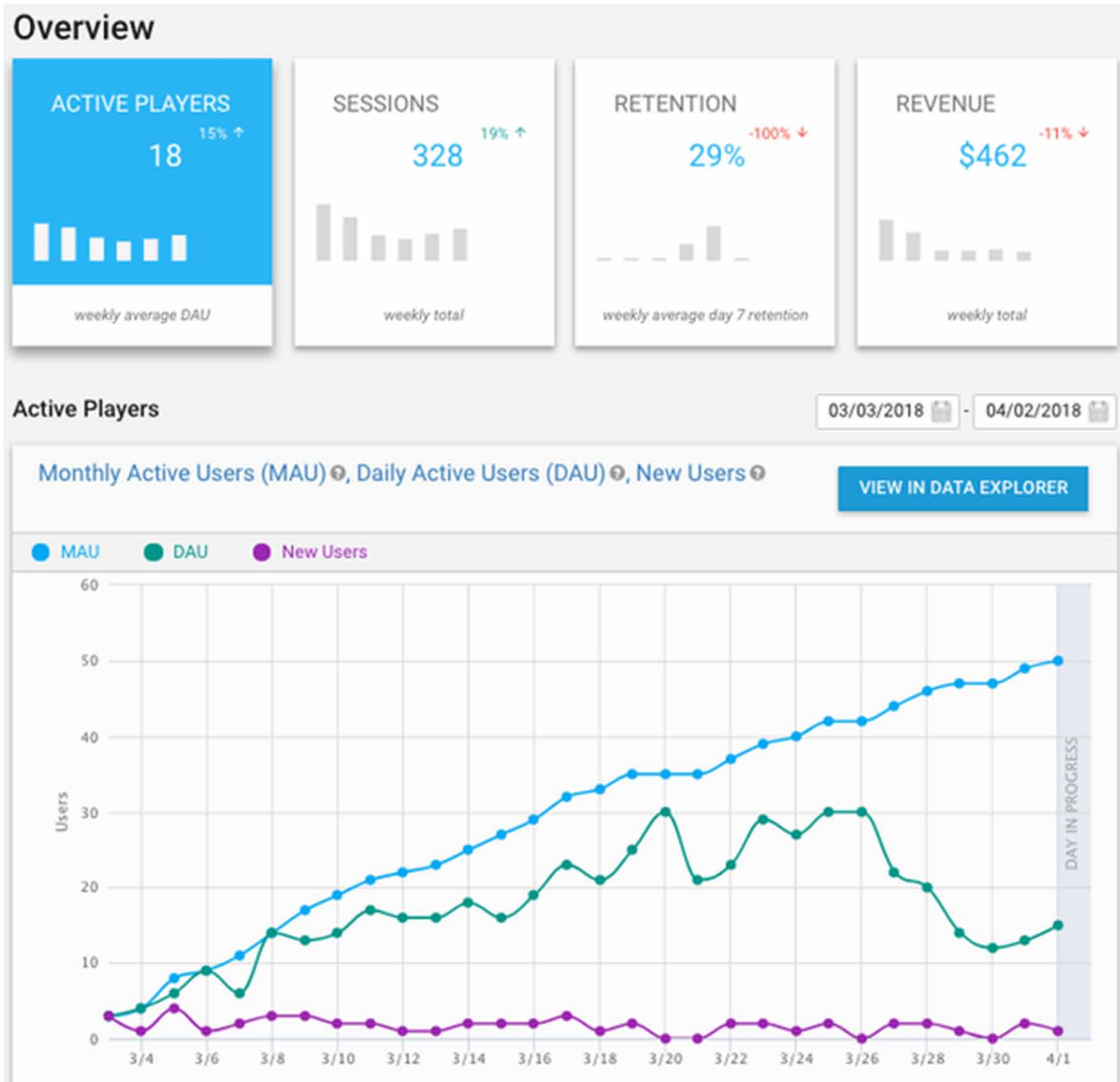
As early as the 1990s, Myron Krueger (1991) predicted that the information society (Castells, 1996) was going to be replaced by one in which experience would be the commodity with value. He also affirmed that, at that time, it was already visible that there were many ways of buying experiences and that access to them was already considered as wealth. For Krueger, virtual reality, in any of the forms in which it has ended up being established (e.g., videogames and their platforms), would be the paradigmatic example of this "experience society."

Accordingly, we have been flooded by immersive products that sell us digital storytelling experiences in packages for all types of profiles. Most importantly, this trend is also reaching other aspects of social reality such as interpersonal relationships (social networks and dating apps), politics (participatory democracy or digital activism), and leisure (escape rooms, interactive, performative, and immersive amusement parks, and e-sports). Nevertheless, this is a trend that goes beyond mere entertainment. For example, it

Figure 9. Facial emotional recognition during the participant interactions where each line represents different types of basic emotions (adapted from iMotions)

is not particularly difficult to find fields that are being structured, to a lesser or greater degree, in terms of experience. Tourism and cultural heritage are areas that have been especially permeated by the staging of experiences and by the sale of experience packages (sightseeing tours, dramatized wine tastings).

Figure 10. Unity Analytics interface showing players' key performance indicators (KPIs) (adapted from Unity Analytics Documentation, 2021)

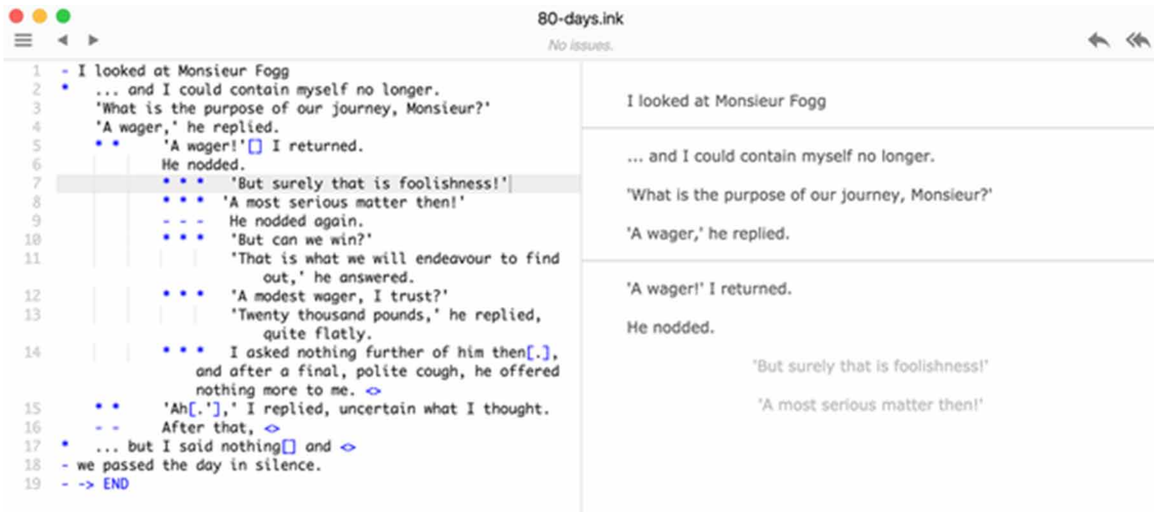


Storytelling and collecting or processing data in real-time have a significant influence on the afore mentioned experiences (Fernández & Puente-Bienvenido, 2015), and today there are numerous examples of great interest tools.

Some Implementations Suggestions in UX Methods and Software for Implementing Interactive and Immersive Storytelling

There are numerous tools in the audiovisual entertainment industry that enable the implementation and the study of highly immersive and interactive storytelling. Some of the tools are very popular, as in the

Figure 11. Inky editor interface (adapted from Inkle Studios, 2021)



case of Twine (an open-source tool for telling interactive, nonlinear stories) and iMotions (research software for access to emotional, cognitive, and behavioral data; see Figure 9).

However, the most potent innovations have appeared thanks to their integration in game engines (which allow informational tracking in real-time and readjust the experience continuously). In the following list three main tools that we consider to have the most significant potential in interactive and immersive storytelling due to their efficiency, accessibility, and synergies (taking advantage of data science and AI in game engines) are presented.

1. **GameTune:** Based on machine learning and AI, GameTune automatically optimizes elements such as progression speed, play patterns, difficulty, and game narratives through A/B testing. This UX tool continuously learns, adjusts, and iterates to deliver the best possible gaming experience, which means more engaged players and a better gameplay experience. GameTune can be used for various problems where the goal is to select the best alternative from A, B, C, (…) for each user. The best alternative is the one that maximizes engagement, player experience, immersive storytelling, conversion, and a custom game-specific reward.
2. **Unity Analytics:** Unity Analytics is a simple but powerful data platform that provides UX data in a video game (mostly related to a player's in-game behavior). Unity collects data by activating events when someone uses an application or game. Unity automatically dispatches a set of core events to collect richer and more in-depth information about how users play a game or experience storytelling. In addition to behavioral events for tracking user experience and player behavior, there are fully customizable events available whose names, purposes, and parameters can be defined as needed. Finally, it is also possible to use heat maps that are significantly useful in UX analysis.

3. **Inky:** Inky is an online tool for writing complex interactive stories that allow narrative designers to play and test their stories in real-time. It uses a powerful narrative scripting language that is

primarily designed for professional game development, though Inky can also be used to write and share choice-based interactive fiction.

CONCLUSION

The following conclusions are either based on the present emergent experiences or are imagined, but close to realistic tendencies. The conclusions covered in this chapter offer final observations in the areas of edutainment, social media, business, media arts, as well as other areas.

Ethical Consideration of UX Interactive and Immersive Storytelling in VR and AR

In the collective imagination of technology users, there are ambivalent discourses about how technical devices facilitate many areas of life and, in parallel, pose numerous risks and uncertainties. These are the so-called benefits and technological development counterparts (Sanmartín & Megías 2020; Sequeiros & Puente, 2019).

Fears and resistances towards technology do not occur uniformly, and certain areas, processes, and practices are perceived in very different ways. Perceptions can range from a partial fear of the implementation of a new technology in the field of interpersonal relationships, for reasons such as dehumanization, to an explicit desire to automate or digitize tasks that do not require much emotional involvement, such as health diagnosis, art, business, or media and audiovisual entertainment.

As a final compilation, we would like to go through a series of examples applied in different academic interest fields.

It is an excellent time for edutainment to develop given the need of more online education. To make full use and benefit of the transmedia and videogame entertainment industries, edutainment will require public institutions to invest in the new generation of interactive entertainment media to develop educational content.

The future of entertainment products linked to digital technology lies mainly in the video game industry. Within the frame of videogames, many possibilities coexist in gameplay, such as using different hardware and software interfaces. However, there is no doubt that gradually VR and AR are becoming relevant tools for game design. The involvement of VR and AR requires new ways of narrating and new possibilities to explore original audiovisual formats. UX-focused studios are already a vital part of the production phases of the new generation of video games. The massive data collection and the increased processing speeds of the new generations of processors allow designers to understand the user' behaviors within simulated or hybridized worlds much more effectively. Despite this advancement, the complexity of human behavior and the myriad factors to consider in the mathematical analysis of the information obtained do not allow absolute independence from game designers and their creative intuition. Nevertheless, the use of UX techniques dramatically simplifies and improves the work and results in game design.

The use of video games as a format for education is not without controversy. Fundamentally, if games become related to education, we are already introducing a political and ideological factor that is difficult to reconcile with an aseptic view of the issue. Merely talking about *serious games* (Clark Abt, 1970) as opposed to *video games* as entertainment introduces an idea linked to the medieval Christian tradition by which games are related to vagrancy, perversion, and crime. If a game is something serious, it will cease to be a game. With videogames, ideas and culture are transmitted in the same way as with any other audiovisual medium. To obtain edutainment, a right balance between serious contents and their presentation must be applied.

What is true is that because videogames have a robust mathematical logic base in their structure, they are beneficial in promoting scientific thinking. The possibility of generating experiences in simulated environments is fundamental not only for leisure, but it is also crucial in simulation. Simulators are, habitually, used to train professionals of different fields, such as pilots and scientists. Moreover, in many cases, the line between the simulator and video game is minimal. For example, many vehicle simulators are also marketed as video games.

On the other extreme, the border between sports and simulators is more complicated. In recent years, new forms of technological and digital sports have been born. Furthermore, these new sportive practices are linked to the immersion in new artificial or hybridized realities. There are already athletes who race professionally in virtual car races with simulators. Drone pilots use FPV glasses (First Person View) with real and augmented information incorporated. Furthermore, there are drone competitions within simulators. The boundaries between reality, simulation, and game are challenging to establish. The game and the ludic experience can arise in any context and any space: real, virtual, or imagined.

The video game is undoubtedly an ideological weapon and is a transmitter of profound values of the societies in which we live. However, the ideological use of games is not something new. In the Greek world's initiation rites and in some of its representations like the Olympic Games, there was a fundamental political and social component for social cohesion. Nevertheless, if we combine the video game's immersive capabilities with massive data management, the anonymity of young users, and, in some cases, severe problems of privacy rights, a very interesting conjunction that can be used unethically by both companies and governments emerges.

Edutainment needs to develop on an ethical and moral base that can communicate important cultural and scientific contents while keeping the game focused on entertainment. UX techniques can help develop better interactive media products that enhance the development of human intellect and spirit and support data to complement accessibility and disability challenges. Edutainment can serve the professors and students to develop better empathic environments where knowledge is built together.

Human relations and social media are fields where digitization, data science, and UX have developed more intensely. Human relationships are increasingly digitally mediated, from applications for dating to applications for sharing social, political, and daily content.

One of the main impacts of AI and data science is the standardization and dehumanization of job categories and skills. This influence of AI has made challenges to new job searchers navigating the online selection processes developed by websites such as LinkedIn. New ways of developing resumes and CVs are being developed to enable AI to at least select the job searcher profile. The exactitude of the words and the lack of synonyms and imagination concerning the interconnection between certain skills makes job search apps very robotic and leaves out potentially interesting profiles that do not correspond to rigid categories.

A series of gamified tools with interesting interactive narratives and storytelling have emerged in this type of context. Using algorithms and data intelligence, game designers and data scientists try to adapt and customize the user experience as much as possible. Thus, technological devices commit the user to immersive stories, suitable matches, challenges, and achievements to unlock, but at what cost? The management of private information, a loss of anonymity, the traceability of data, and the segmentation of socio-demographic data for marketing purposes are some of the tolls to users pay in exchange for immediacy, permanent connection, access, and personalization.

Ambivalent desires for digitization and customization arise in areas where greater penetration is desired, coexist with others where the public shows certain fears for their potential risks. Thus, utopian discourses of accessibility, immediacy, integration, and the breaking of limits coexist in parallel with other more dystopian visions associated with surveillance, control, deprivation, and inequality (of access and management). Thereby, desires and expectations regarding the progressive introduction of AI and data science in our social interactions are traversed by situations of socio-demographic variability and some groups are made vulnerable to being exposed to the less attractive effects of technological developments' progressive penetration (Sanmartín & Megías 2020). For example, people with a lower educational level perceive more significant risks and vulnerabilities associated with technological development, because they are the ones who are most exposed to its risks. Conversely, highly educated groups perceive technology and UX in a more positive, libertarian, and innocuous way (technophilic or utopian vision).

DEDICATORY

In Memoriam of our beloved friend Jorge Mora Fernández (1976-2021), Interactive Media Researcher (University of California, San Diego, Arthur C. Clarke Center in Human Imagination), colleague, storyteller, and navigator of the Virtual Seas.

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KEY TERMS AND DEFINITIONS

Game Design: Techniques and processes used to design the rules and contents of a videogame.

Game Design Document: Document with all the design information of a videogame. It´s the main document for designers, programmers, and artists in a videogame project.

Game Engine: The core software for a game to properly run. It allows the design, creation, and operation of a videogame.

Gameplay: The game experience that emerges from the interaction between the game design and the player.

Heatmap: A graphical representation of data in the form of a map in which colors represent data values.