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Playability: analysing user experience in video games

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Currently, few studies focus on analysing the degree of the Player eXperience (PX) in video games. Video games have now become interactive entertainment systems with a high economic impact on society; these are interactive systems characterised by their subjectivity, which differ from other systems in that their main objective is to entertain and amuse the user (player). This work discusses the analysis and evaluation of the User eXperience (UX) in interactive entertainment systems, exploring how usability, given its definition, objectives and the fact it is one of the main dimensions of UX, is not sufficient to characterise the PX, giving rise to a new concept: Playability. In this paper, we present a framework for the analysis and evaluation of the UX in video games. The results show the need and importance of a framework to help us understand and measure the experience that players feel using these types of interactive systems, in order to improve the experience during play time. The proposed framework characterises the experience using attributes to identify and properties to measure UX. It thus provides a multifaceted analysis mechanism to assess the impact of the gaming experience and its relationship with the elements of a video game. We therefore present a system to represent UX based on this framework, with the aim of ensuring and measuring a satisfactory experience of the entertainment system. Finally, we discuss a practical experiment in which an evaluation of the playability of a commercial video game was carried out using the methods proposed in this work.

Keywords: playability; user experience; usability; video games; interactive systems

1. Introduction

Human–Computer Interaction (HCI) is the discipline that studies and promotes the 'human factor' in computer systems in order to enhance the User eXperience (UX) of such software or hardware products (Hewett 1992). It is essentially the study of the interaction between people (users) and computers.

When an interactive system is used, we must analyse its purpose for the user. This is the functional utility of the system when performing a defined task with defined objectives or using well-defined goals; this means productivity. We must also measure and evaluate how users can interact with the functionality that the system offers. It is here that the concept of Usability appears as a measurement of the UX.

Video games are highly interactive systems whose main goal is to entertain users (players) that interact with them in order to have fun. Nowadays, video games are the most economically profitable entertainment industry. Due to the nature and design of video games, UX is enriched by recreational, cultural and other subjective factors that make analysis and evaluation difficult using traditional methods commonly used in interactive systems (for example, usability evaluation methods in desktop systems). Having mechanisms that allow us to evaluate the UX in video games is a key objective to ensure success in an increasingly competitive market saturated with diverse products, and the existence of models that characterise the UX and provide mechanisms to analyse it throughout the video game development process becomes a must (Zaphiris and Siang Ang 2007, Voida and Greenberg 2011).

The purpose of this work is to show that the traditional analysis techniques for measuring UX, such as usability, are not sufficient to analyse the experience in a gaming system. The existence of a framework for the analysis and evaluation of the UX is required in these types of interactive systems, which are based on playability, with the following objectives:

- To be able to measure the degree of satisfaction of players in order to help define a positive UX within an electronic entertainment system: Playability.
- To characterise the Player eXperience (PX) (Playability) based on measurable and quantifiable attributes and properties.

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- To evaluate and understand the impact of the elements of a video game on UX across diverse player profiles thanks to a Playability Model.
- To apply a framework for evaluating and improving playability in the video game development process, in order to improve the UX using playability techniques.

This paper is organised as follows: the following section looks at how UX differs from the experience felt by the player with video games (PX). We discuss here how evaluation methods used in UX, such as usability techniques, are not sufficient to fully characterise the UX in this field. The third section presents playability as a measure of the characterisation of the UX in video games, featuring a series of attributes and properties representing systems and facets that facilitate its analysis and measurement. A practical example of the evaluation of UX in video games is shown in Section 4, using our proposal of a playability framework that provides us with detailed information on the PX and which parts of a video game have greatest influence on it. This evaluation was carried out with a commercial game by students of the Master in Software Development Course at the University of Granada (Spain).

Finally, in Section 5, we discuss the advantages offered by the Playability Framework to gain information about UX when evaluating or designing a game for specific target markets and applications. We then present some examples of future work and research arising from this study.

2. Playability: from UX to PX in video games

User eXperience is a term that covers known multidisciplinary HCI terms and it goes a step further in investigating all the sensations experienced by the user when performing a particular task in a particular interactive system. User eXperience covers pragmatic and hedonic properties of the interaction (NNG 2003, Law *et al*. 2009, ISO 2010, Law and van Schaik 2010, Idoughi *et al*. 2011, Shin *et al*. 2011). Usability (Nielsen 1993, ISO 1998, Shneiderman 2000, Dix 2004, Batch and Scapin 2010) reflects an important facet of the UX. However, it is generally focused on the pragmatic properties of the interaction process. According to ISO (2010, 2011), Usability can be defined as being subsumed by UX and UX is an elaborated form of Satisfaction (one of the three usability metrics) and is focused on the hedonic properties of the interaction process (Axelrod and Hone 2006, ISO 2011).

Video games are interactive systems designed to exploit the UX when used by players, because their main objective is to exploit the emotions/feelings of the user and ensure fun and entertainment for the player (hedonic properties) (Barr *et al*. 2007, Voida and Greenberg 2011).

It is the recreational nature of video games that sets them apart from other traditional interactive systems, such as 'Desktop System', which is designed to perform a specific task. Trying to identify the UX by analysing the degree of utility of Usability (a very common technique with desktop systems) is insufficient, because we must add many 'subjective characteristics' of the player to the 'functional values' in order to identify and characterise the 'real' UX (see Table 1).

The PX with a video game can be quite extensive, subjective and more specific when compared with a traditional interactive system, requiring the identification of a property to analyse and measure these types of experiences. The property that characterises the PX or UX in entertainment systems is commonly called *Playability*.

2.1. Playability: literature review

Playability is a term used in the design and analysis of video games that describes the quality of a video game in terms of its rules, mechanics, goals and design. It refers to all the experiences that a player may feel when interacting with a game system. Sometimes, the experience is related with the different ways of interaction among players (Voida and Greenberg 2011).

One of the most commonly used definitions of playability is 'the degree to which a game is fun to play and is usable, with an emphasis on the interaction style and plot-quality of the game; the quality of gameplay' (Usability-First 2009). Playability is affected by the quality of the storyline, responsiveness, pace, usability, the possibilities to customise it, control, intensity of interaction, intricacy and strategy, as well as the degree of realism and the quality of graphics and sound.

Table 1. Different goals to achieve a positive User Experience (UX) and Player Experience (PX) (Lazzaro 2008).

UX goals: productivity	PX goals: entertainment
Task completion	Entertainment
Eliminate errors	Fun to overcome obstacles
External reward	Intrinsic reward
Outcome-based rewards	Process is its own reward
Intuitive	New things to learn
Reduce workload	Increase workload
Assumes technology needs to be humanised	Assumes humans need to be challenged

There are two clear lines of research and study of Playability, into which the most existing work and experiments can be classified. These lines are:

- The analysis and measurement of playability as a quality measurement of the different video game elements and the impact of experience on the user.
- The evaluation of playability as a 'specific usability' and UX measurement in the context of video games.

In this section, we describe briefly the most representative works of each specific line of research, but 'there are some excellent guides/books to discover' and the most important references in playability scientific community and research works can be found in Bernhaupt *et al*. (2008), Bernhaupt (2010), Nacke *et al*. (2009b) and Isbister and Schaffer (2008). Probably, Playability is related with video games and entertainment systems, but the know-how to evaluate or analyse it is a fundamental factor in other kinds of video games, for example, serious games (Olsen *et al*. 2011).

2.1.1. Playability as a measurement of the quality of video game elements

Many authors consider playability as a representative element for the quality of video game elements and player–game interaction. Rollings and Adams (2003) present the 'triad of playability', which contains three key elements for identifying the playability of a video game. These are: Core Mechanics (rules, objectives and goals to achieve), Storytelling and Narrative (story line and narrative technique used in the video game) and Interactivity (set of elements that the player can see, hear and interact with in the virtual world). In 'The Art of Game Design' (Crawford 1984), the author indicates that playability happens when the gameplay is right and is properly executed, thus observing the importance of interaction with the elements of the video game.

Ben Shneiderman (2004) in 'Designing for Fun: How Can We Design User Interfaces to Be More Fun?' shows that user interfaces for playing should use clear and direct metaphors for the players, applying attractive graphics, animation and sounds. In Ye and Ye (2004), the authors consider that the dialogue between video game and player is the basis for the experience felt by the player; it is the interaction that causes most 'emotional conflicts'. For Swink (2007), playability is based on the combination and proper structuring of the game elements during the play time. Druin (2002) remarks the importance of the target, for example, the role of the players (adults or children) in the design of new technology.

Furthermore, Akihiro Saito (2008) indicates that the PX is identified by 'Gamenics': the quality of play, the quality of the platform on which a game runs and the mechanics of the game (GAme + MEchanics + electroNICS). The work established four principles to consider within the proposed guidelines:

- Intuitive User Interface (emphasising ease of use).
- Played without manual (the players should not feel confused about what to do and how to do it).
- Interfaces that help overcome the traditional learning curve (producing excitement to the player helped by the device or game controller).
- Reality: we should bear in mind that the player is familiar with their environment and the context of life and thus, when designing a video game, we need to provide the user with familiar interaction mechanisms to ensure his or her integration with the virtual world.

Norman (2004) and Lazzaro (2008) propose that one of the secrets of playability is the management of emotions, where motivation is a key factor in generating a positive experience for the player. If players are continually motivated, the PX will improve. Lepper and Malone (1987) proposed a number of factors that help improve playability and user motivation, namely: challenges, curiosity, control and fantasy. Affective improves the final experience in video games, thanks to the quality of the art facet (Bialoskorski *et al*. 2010). Aesthetic of the elements of the video game also has influence in the PX evaluation and testing (Sauer and Sonderegger 2010).

Regarding the interactive component, we should highlight the need for the correct level of immersion during the play time. Consequently, studying the adequacy of immersion is another factor that can help improve playability (Järvien *et al*. 2002). This is when a user 'flows' with the game, meaning he or she is in a state of optimal 'flow' (Csikszentmihalyi 1990). Järvien offers a different point of view to analyse the playability in video games, without explicit correspondence with the elements of video games.

2.2.2. Playability: usability evaluation in video games

Another line of research in the field of playability and PX focuses on defining playability as 'the usability in the context of video games', in which usability is understood as a traditional property of the UX.

One of the most referenced works in this area is Federoff's (2002) proposal. Federoff focused on

developing a set of heuristics to measure 'playability' based on Nielsen's 12 main points (Nielsen and Mack 1994) in a video game context. These heuristics are associated with three groups of items that appear in a video game: user interface, the game mechanics and the gameplay. This classification resulted from the work by Chuck Clanton (1998), who indicated that the usability of a video game is encapsulated and can be analysed with these groups of items.

Following the line of heuristics and evaluation criteria of playability and usability in video games, we would like to highlight the proposals of H. Desurvire and Korhonen (Desurvire *et al*. 2004, Korhonen 2006, Korhonen and Koivisto 2007, Pinelle *et al*. 2008, Desurvire and Wiberg 2009). These works analysed playability using heuristic evaluation based on specific video game usability heuristics. These heuristics focus on the understanding and control of the game and are specialised for specific platforms, such as mobile phones.

Some interesting works are more focused on how to evaluate the PX or modelling the user emotional state applying biometric techniques and playability models (Mandryck *et al*. 2006, Nacke *et al*. 2009a, van den Hoogen *et al*. 2008, van den Broek 2010, González Sánchez *et al*. 2011) or analysing the UX through specific game and gameplay metrics (Tychsen and Canossa 2008, Canossa and Drachen 2009) – using biometrics or physiological control to enhance the interaction with the game system (Nacke *et al*. 2011) or exploring the player's perception towards biometric technology (Byun and Byun 2011).

We should also mention a series of studies which are not as related to Nielsen's ideas of evaluation, but which focus on improving the PX by incorporating playable elements into video games. Björk's proposal offers a set of patterns and guidelines to game developers to increase the usability (playability) in video games (Björk *et al*. 2003). Nokia (2010) also provide game designers with a number of video game guidelines for improving usability and PX with mobile games. But it is important to readapt the experience to the user cross-cultural and location issues (Chen *et al*. 2005, Jagne and Smith-Atakan 2006); or promotes the social game implementing better mechanics for the collaboration among players (Padilla *et al*. 2009, Lindley *et al*. 2011).

Another important research line is the one which uses questionnaires to assess the UX . In this context, we can highlight several works. The most significant is Game Experience Questionnaire (GEQ), which reliably distinguishes between seven different dimensions of PX: Sensory and Imaginative Immersion, Tension, Competence, Flow, Negative Affect, Positive Affect, and Challenge (de Kort *et al*. 2007, IJsselsteijn *et al*. 2007, Gajadhar *et al*. 2008). However, there are others which are worth mentioned: Core Elements of the Gaming Experience Questionnaire (CEGEQ) (Calvillo-Gomez *et al*. 2010) and other works derived from them (Poels *et al*. 2009, 2010, Lai-Chong and Sun 2012).

Moreover, it is possible to find style guides that promote the playability and accessibility in video games (IGDA 2004, Bierre *et al*. 2005, Medialt 2008, Grammenos *et al*. 2009, Ont and Pozzi 2011). Game accessibility studies are focused on players with disabilities and how they could benefit from the different opportunities that video games offer them. Playability is a crucial factor, because to have the opportunity of combine accessibility techniques to properties to characterise and improve the entertainment of the player with the video game. The important references in this area are collected in Yuan *et al*. (2010) and Westin *et al*. (2011).

3. Playability: characterising the UX in video games

In Section 2, we examined playability as a 'hot topic' in the HCI scientific community (Zaphiris and Siang Ang 2007). However, each study has been performed from different perspectives and with different objectives, thus giving rise to many playability definitions and proposals. These differing objectives may be to improve immersion, motivation, emotion, usability, interactiveness, intuitiveness, fun, and so on.

There is a clear lack of a common definition of playability or not so ambiguous definition, attributes to help characterise the PX, properties to measure the video game's development process and mechanisms to associate the impact/influence of each video game element in the PX. We consider this a significant 'gap', since the different definitions of playability require different criteria to measure it: there are no universals.

Furthermore, the lack of attributes to characterise playability means that each study offers a solution, which relates only to its particular scope and interest, making it hard to extrapolate these solutions and apply them to different video games. Playability is also considered as the 'only' usability in many contexts, which makes it difficult to obtain all the relevant information about the PX.

Furthermore, although studies and works that offer different guidelines and heuristics or questionnaires to improve and evaluate playability exist, most studies are based on usability and do not include the relationship these heuristics/questionnaires may have with specific elements and characteristics of a video game. It is of interest to identify the impact that these elements may

have on the overall interaction experience between video game and player.

Finally, Playability in order to characterise the UX in video games must represent the pragmatics and hedonic factors of the experience during the interaction process. It means the experiences related to: emotions, aesthetic, social, be immersed, quality of play, game elements, time spent playing and so on.

In this section, our main objective is to *give identity* to the concept of playability, and thereby to create an accurate and comprehensive *definition* of the term, using *attributes* that characterise the UX in video games and *properties* used in the measurement process. The proposed *model* is intended to be used in the analysis *of the PX* from the beginning to the end of the video game development process, featuring mechanisms for quantitative and qualitative assessment of the experience and the relation to the different elements of a video game.

We also present a series of facets that allow us to simplify the analysis of playability and the relationship of the UX with the different elements of a video game. Finally, we show mechanisms to represent playability based on the value of its attributes/properties and the impact achieved by each facet, in order to facilitate the evaluation of the PX.

3.1. Playability: attributes and properties which characterise the PX

As already stated, Playability is based on Usability but, in the context of video games, it goes much further. Furthermore, Playability is not limited to the degree of 'fun' or 'entertainment' experienced when playing a game. Although these are primary objectives, they are concepts so diffuse as to require definition using a broad set of attributes and properties to measure the PX.

We define Playability as: 'a set of properties that describe the PX using a specific game system whose main objective is to provide enjoyment and entertainment, by being credible and satisfying, when the player plays alone or in company' (González Sánchez *et al.* 2009a,b).

It is important to emphasise the 'satisfying' and 'credible' dimensions. The former is more difficult to measure in video games than in desktop systems due to the high degree of subjectivity of non-functional objectives. Similarly, the latter depends on the degree to which players assimilate and become absorbed in the game during play time – also difficult to measure objectively.

Playability represents the degree to which specified users can achieve specified goals with effectiveness, efficiency and, especially, satisfaction and fun in a playable context of use.

Playability is characterised by the attributes that exist in Usability but that have different meanings. For example, 'Learnability' in a video game could be experienced as challenging. However, 'Learnability' should not only offer the player the satisfaction of the learning process itself, but should also expand his or her knowledge of concepts and techniques, which can later be applied to resolve new game challenges. After analysing several video games and their different characteristics using different research works, we propose a set of seven attributes to characterise Playability in order to complete and integrate them in a model to characterise the experience in this kind of systems. They are: Satisfaction, Learnability, Effectiveness, Immersion, Motivation, Emotion and Socialisation. Furthermore, we highlight a number of properties for each attribute to measure the degree of experience offered by a game.

To perform the measurement of every attributes and properties of playability it is advisable to take into account the different player profiles[1] and video game genres. The meaning or importance of attributes of playability may differ depending on these elements. Figure 1 illustrates the attributes of playability and the properties to identify or measure them. The figure shows whether the attributes and properties are more related, in terms of UX, to the 'product' (video games in this work) or to the interaction process and use (player–game interaction), and whether these properties are more influenced by the player's preferences (player's vision) or by a group of players (multiplayer games) (González Sánchez 2011).

We will now outline in more detail the attributes and properties of Playability in order to subsequently measure them, and give examples of where they can be identified in a video game:

3.1.1. Satisfaction

We define this as the gratification or pleasure derived from playing a complete video game or from some aspect of it, such as mechanics, graphics, user interface, story, and so on. Satisfaction is a highly subjective attribute that is by definition difficult to measure as it depends on the preferences of each player, which in turn influence the satisfaction derived from specific elements of the game (characters, virtual world and challenges). We characterise Satisfaction using the following properties:

- *Fun:* The degree of fun experienced is one of the fundamental properties of player satisfaction. The main objective of a video game is to entertain; hence a video game that is not fun to play could never satisfy players.

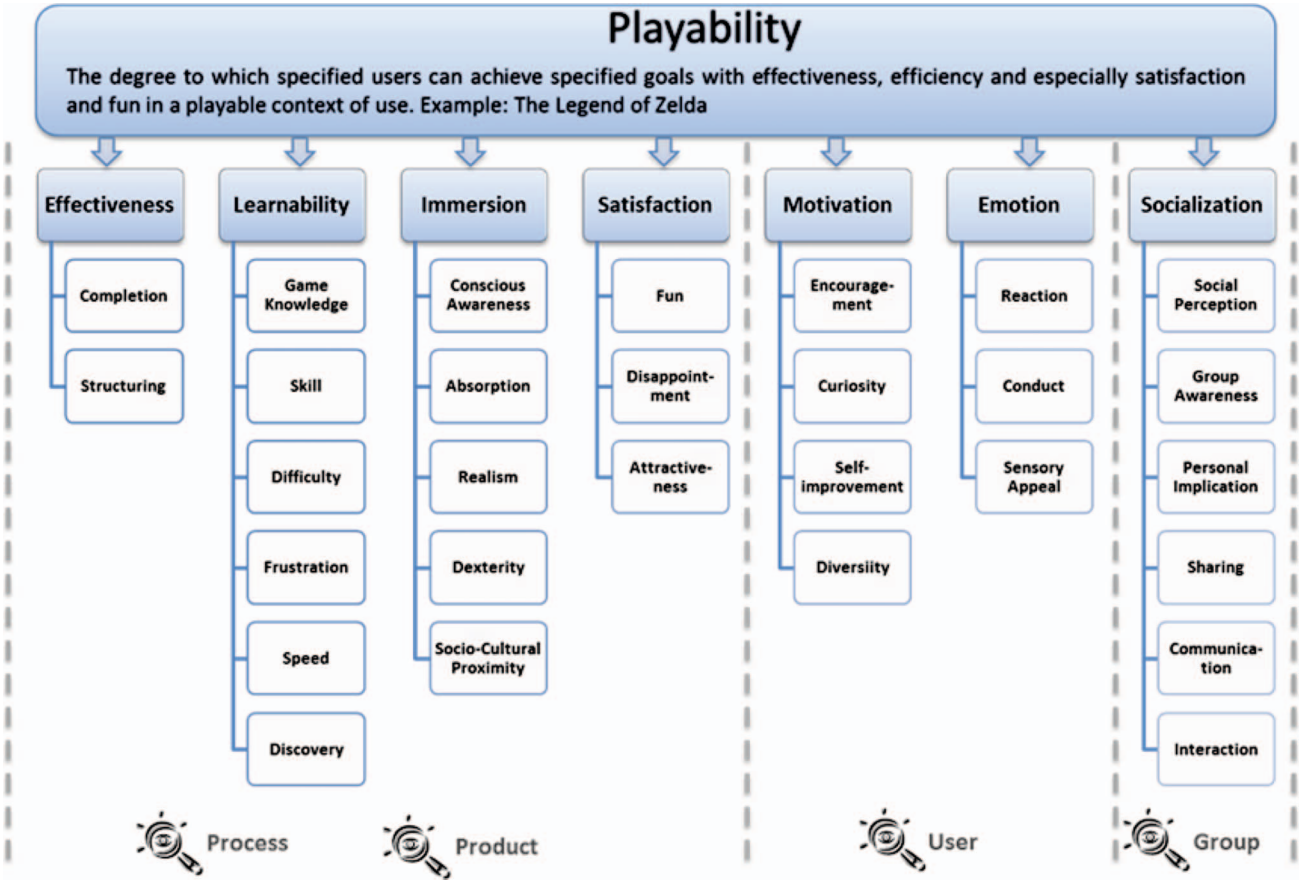

Figure 1. Playability model: attributes and properties which characterise the Player Experience.

- *Disappointment:* The degree of Disappointment is a negative property of satisfaction and is linked to, among other things, the player's personality. We should ensure that players do not feel so disappointed or uneasy while playing a video game that they abandon it altogether.
- *Attractiveness:* The player's pleasure and satisfaction with particular aspects of the game that are of interest and gain the confidence of the player.

3.1.2. *Learnability*

We define this as the player's capacity to understand and master the game's system and mechanics (objectives, rules, how to interact with the video game, and so on). Desktop Systems try to minimise the learning effort, but in video games we can play with the 'learning curve' according to the nature of the game. For example, on the one hand, a game may demand a high initial skill level before playing, or it may put the player on a steep learning curve during the first phases of the game, to help them understand and master all the game's rules and resources so that they can use them virtually from the outset. On the other hand, players can learn step-by-step in a guided fashion when they need to develop a particular ability in the video game. We propose the following properties to characterise 'Learnability':

- *Game Knowledge:* A player's prior knowledge of a video game will influence the degree to which they are affected by the learning curve proposed by the game. A habitual player in particular genres or in previous versions of a game has some experience that naturally means they will find it easier to assimilate new concepts and understand how to play.
- *Skill:* Skill is demonstrated by how the player plays. Once they have understood and assimilated the game's objectives and rules, how they address the game's challenges to reach the different objectives and rewards is a matter of skill. A highly skilled player will find it easier to learn the game's system, because they possess sufficient ability to overcome challenges and to

develop their skills further during play. We distinguish two types of Skill:

- *Interactive Skill:* The ability to interact effectively with the controls and carry out specific actions or special movements that represent specific events in the virtual game world.
- *Cognitive Skill:* The ability to understand, assimilate, remember and use different game concepts or information.

- *Difficulty:* The degree of difficulty in a video game is a key factor in the learning process, because it encourages players to assimilate and master the game's dynamics to achieve various goals. Difficulty may be higher or lower depending on how steep the learning curve is, relative to the player's skills and how long they have been playing. A high Difficulty level can provoke a greater effort by the player to learn how to play.
- *Frustration:* This property is often part of the learning process and is produced by the player's feelings of unease when they are unable to achieve a particular challenge or objective, or when failing to understand certain concepts. If the player feels too frustrated, this can directly reduce Playability.
- *Speed:* The speed with which new concepts and contents are introduced into the game directly affects the learning process. A high level of Speed can prompt the player to exert a high level of effort in the learning process. A low Speed can provoke boredom, which can have a negative effect on Playability.
- *Discovery:* The degree of Discovery of new contents (rules, rewards, goals, and so on) is a key factor that helps reduce the effort required in the learning process. Some video games guide or reveal to the player how to play, using tutorials, different training levels or step-by-step actions using events (QTE Events[2]). The different resources for enabling Discovery support better assimilation of the game's various contents so that the player needs successively less time to improve his abilities to achieve the game's objectives.

3.1.3. *Effectiveness*

We define effectiveness as the time and resources necessary to offer players an entertaining experience whilst they achieve the game's various objectives and reach the final goal. An 'Effective' video game is able to engage the player's attention from the outset through to the very end of the game. Effectiveness can be analysed as the correct use of the challenges by the player throughout the game, the correct structuring of the objectives of the game and/or the best adaptation of the controls to the actions in the game. We identify Effectiveness as having the following properties:

- *Completion:* Due to the different users' profiles, the degree of completion may affect to the final experience. For 'experienced players' who love to achieve optional challenges or trophies, a video game is more effective if the percentage of Completion is high. In other words, where a video game is played near to 100% across all game scenarios, it can be considered effective in that the player found no parts of the game uninteresting improving the final experience. However, other player profiles (i.e. casuals) have a complete experience with the main challenges of the game and they are not interesting in secondary challenges, goals and items. Completion is principally reflected in the number of optional elements achieved in a game, but it should be measured according to the different players profiles.
- *Structuring:* The structuring of the game elements (that is, where, when and how they appear in the Gameplay) is a further property of Effectiveness. A video game is well structured when it achieves a good balance between the various objectives to be achieved and the different challenges to overcome, such that the players remain engaged and enjoy themselves throughout the entire game time. The degree in which the game is structured helps to develop the effectiveness of the Gameplay (i.e. number of challenges per level, or number of challenges per time). In addition, this property offers information to re-adapt the experience of the Gameplay to different player profiles (i.e. adding new challenges for expert players).

3.1.4. *Immersion*

We define this as the capacity of the video game contents to be believable, such that the player becomes directly involved in the virtual game world. This intense involvement means that the player effectively becomes part of the virtual world, interacting with it and with the laws and rules that characterise it. A video game has a good Immersion level when it achieves a balance between the challenges it presents and the player abilities necessary to overcome them. To characterise Immersion, we propose the following properties:

- *Conscious Awareness:* The degree to which the player is consciously aware of the consequences

of their actions in the virtual world is one of the fundamental properties of Immersion. The player's conscious awareness of a video game is represented in their mental model for understanding the game's objectives, goals, challenges, controls, rewards and any factor which may affect Gameplay. Understanding what happens as a result of carrying out a particular action helps the player imagine what to do next and to develop the necessary abilities to overcome challenges.

- *Absorption:* The degree of absorption of the player in a video game is one of the most recognisable properties of Immersion. A player who is completely absorbed is involved in the Gameplay to such a degree that they focus all their abilities and attention on overcoming the game's challenges.
- *Realism:* The level of realism of a video game has a direct influence on its immersion capacity. Realism is not only hyper-realistic graphics and sounds; it means the capacity of the video game contents to be believable for players. The more realistic a video game is, the greater the Immersion of the player we obtain thanks to consistent sceneries, mechanics and rules for Players when players are interacting with them within the virtual game world. These characteristics of the Gameplay help to be believable for players and improve the immersion. Realism helps the player focus on the game's challenges, rules and objectives.
- *Dexterity:* This refers to the player's dexterity in carrying out different movements and actions in the virtual world in which they are immersed. We note two types of dexterity:
  - *Interactive Dexterity:* The player's ability to interact with the game's controls and realise different combinations of movement that are translated into specific actions in the virtual world.
  - *Virtual Dexterity:* The ability to realise different movements and necessary actions inside the virtual world. It can be deduced that to achieve optimum player Immersion, interactive movements (using the game controls) need to be as similar as possible to those carried out in the virtual world.
- *Socio-Cultural Proximity:* Video Games have more or less immersive efficacy depending on the degree of socio-cultural proximity to the player – appropriate to their age or gender, for instance. The metaphors and atmosphere used in the game, even when realistic, can still reduce the Immersion of the player if they do not reflect certain socio-cultural characteristics that the player can identify with. Video Games that are oriented to a specific gender or age of player tend to produce the greatest immersive effect, reflecting as they do the specific cultural characteristics of the target population.

3.1.5. Motivation

We define this as the set of game characteristics that prompt a player to realise specific actions and continue undertaking them until they are completed. To achieve a high degree of Motivation, the game should offer a set of resources to ensure the player's perseverance in the actions performed to overcome challenges. By 'resources' we mean different elements to ensure positive behaviour in the interpretation of the game process, thereby focusing the player on the proposed challenges and their respective rewards, showing the relevance of the objectives to be achieved, and encouraging the player's confidence and pleasure in meeting and achieving challenges. We characterise Motivation as having the following properties:

- *Encouragement:* The level of confidence felt when facing new game challenges and the possibility of reaching new game objectives affects the degree of player encouragement. A video game must minimise frustration levels in order to improve a player's Motivation (positive game encouragement). For example, an extremely low reward for a new challenge can potentially increase the player's sense of frustration and discouragement. Similarly, a poorly designed video game control that makes it almost impossible for a player to carry out necessary actions in the virtual word will cause them to lose interest in the game.
- *Curiosity:* One of the basic video game techniques for improving player Motivation is to stimulate intrigue in the discovery of new game elements – in other words, curiosity about what will come next. Curiosity can be generated by the inclusion of optional features, objectives and challenges that offer the player the freedom to interact with a greater number of elements.
- *Self-improvement:* The degree of player or character improvement is a property that characterises player Motivation. Self-improvement occurs when the player or their character develops their ability and skills – be it to overcome specific challenges, or simply because the player enjoys employing a particular skill.
- *Diversity:* The number of different elements in a game has, we believe, a direct influence on player Motivation. Diversity of game elements makes

the game more attractive to players and reduces the likelihood of monotony. Examples of such elements might include 'chance and randomness' systems that make it impossible to resolve challenges through trial and error, or alternative ways to overcome challenges according to personal taste or ability.

3.1.6. Emotion

This refers to the player's involuntary impulse in response to the stimulus of the video game that induces feelings or a chain reaction of automatic behaviours. The use of Emotion in video games helps achieve an optimum PX by leading players to enter different emotional states. We characterise Emotion as having the following properties:

- *Reaction:* The player reacts to a video game because the system is a source of different stimuli. The player's initial reaction may then trigger several types of emotion. Four basic types of player reaction can be identified: *Internal*, this is an automatic reaction, which is generated through the senses (i.e. feeling disgust at the sight of blood); *Behavioural*, this is stimulated by the player's actions and the consequences of these whilst interacting with the video game (i.e. spontaneously cheering when solving challenges and obtaining rewards); *Cognitive*, this is provoked by the thoughts and memories that a player has when playing the game, reflecting either their own life or past experiences of the game; and *Social*, this refers to the emotions and reactions experienced by players when playing in company that can provoke an entirely new way of experiencing the game compared to when playing alone.
- *Conduct:* Video Games are behavioural mechanisms in that they can influence the conduct of the player during Game time, by leading them through different emotions thanks to the stimuli they provide. Video Games are 'emotional vehicles', which enable the player to remain emotionally engaged for the entire duration of the game and thus improve their interaction with the virtual world.
- *Sensory Appeal:* Since the game needs to transmit a series of emotions to the player, it needs to use different sensory channels to stimulate the player's senses. The use of different channels, such as graphics to stimulate the player visually, triggers a cognitive reaction in the player, which enables them to process the game whilst feeling the emotions it induces.

3.1.7. Socialisation

We define this as the set of game attributes, elements and resources that promote the social dimension of the game experience in a group scenario. This kind of collective experience makes players appreciate the game in a different way, thanks to the relationships that are established with other players (or with other characters from the game). Game Socialisation allows players to have a totally different game experience when they play with others and it promotes new social relationships thanks to interaction among players. Socialisation is also at work in the connections that players make with the characters of the video game. Examples of this might include: choosing a character to relate to or to share something with; interacting with characters to obtain information, ask for help, or negotiate for some items; and how our influence on other characters may benefit, or not, the achievement of particular objectives. To promote the 'social factor', new shared challenges need to be developed that help players join in with and assimilate the new game dynamic, creating a set of collective emotions where players (or characters) encourage and motivate themselves and each other to overcome collective challenges. We propose that Socialisation has the following properties:

- *Social Perception:* This is the degree of social activity used and understood by players, who experience a more extensive game in a multiplayer context than they do playing on their own. It is important to ensure that players appreciate the difference between the two contexts, so as to increase their social awareness.
- *Group Awareness:* This refers to the conscious awareness of players of being part of a 'team', and of sharing common objectives, challenges and game elements. Players must understand that they are a part of a group and that the success of the group depends on achieving shared objectives. The game should be designed in such a way as to encourage each player to contribute their experience, without undermining other players. Sometimes a player, together with other characters, needs to understand and negotiate group interests according to the game dynamics.
- *Personal Implication:* The Personal Implication of the individual with the group in the dynamic of the game is a further property of Socialisation. The player needs to be aware that individual achievement leads to group victory. Hence, rules, challenges and objectives need to be developed that help raise the player's awareness of their role in the group's success, and their identification with it.

- *Sharing:* Shared game resources, and how they are managed, are key factors in Socialisation in video games. When a player plays within a group, the objectives are shared, but so is the responsibility for working towards them by players and characters. For example, players may exchange information to resolve particular challenges.
- *Communication:* The extent of communication among group members is one of the defining factors of Socialisation in a game. Multiplayer video games should offer communication mechanisms that enable optimal interchange of information among players. Some of the more popular communication mechanisms include instant messaging, blackboards and video/voice calls, as well as mechanisms which need face-to-face communication in front of the game device itself.
- *Interaction:* How the group perceives the rules of the game or how members will interact to achieve the objectives are crucial properties of Socialisation. The way in which characters or players relate to each other allows objectives and challenges to be overcome in different ways according to the interests fostered by interaction among group members. We highlight the following types of interaction: *Competitive*, when a player plays to achieve personal success; *Collaborative*, individual success is replaced by group success; and *Cooperative*, Players can have their individual goals whilst forming a group to benefit themselves, thanks to the help of other members. The majority of games implement cooperation techniques among players or characters to achieve the most valuable rewards in the game.

3.2. Measurement of playability: facets and surfaces of playability

One of the objectives we now introduce is to indicate how to measure or quantify Playability (the UX). The process of playability analysis may be complicated by the amount of non-functional goals that affect the PX, which is why the analysis must be broken down into different points of view. It is then possible to facilitate the relationship between the elements of a video game and its impact on playability.

We should stress that playability is not a unitary and indivisible concept but an interrelated set of multiple playabilities that identifies the overall UX. For any game, multiple playabilities interact with each other to show the 'global' playability of a video game. In González Sánchez (2011) and González Sánchez *et al.* (2009b), a classification based on different perspectives is proposed and it is called 'Facets of Playability'. Each fac*et al*lows us to identify the different attributes and properties of Playability that are affected by the player–game interaction process.

An additional objective that we propose in this work is the ability to relate to specific elements that may appear in the video game and their impact on the UX. We use the proposed conceptual model of video game elements (González Sánchez and Gutiérrez 2010), which details the most common elements of a video game based on an ontology and the most important relationships that exist between the elements that are part of video games.[3] Thus, each facet allows us a mechanism by which to identify the different attributes and properties of Playability that are affected by the different elements of video games.

The six Facets of Playability are:

- *Intrinsic Playability:* This is the Playability inherent in the nature of the video game itself and how it is presented to the player. It is closely related to Gameplay design and Game Mechanic. In this facet, for example, we can analyse the game's rules, goals, objectives, rhythm and other mechanics.
- *Mechanical Playability:* This is related to the quality of the video game as a software system. It is associated with the Game Engine, with particular emphasis on, for example, the fluency of the film scenes, correct lighting, sound, music, animated graphics and characterisation, as well as communication systems in a multiplayer video game.
- *Interactive Playability:* This is associated with player interaction and video game user interface development, for example, interaction dialogue and game controls. This aspect of Playability is strongly connected to the Game Interface.
- *Artistic Playability:* This facet relates to the quality of the artistic and aesthetic rendering in the game elements – visual graphics, sound effects, music and melodies, storyline and storytelling – and how these elements are executed in the video game.
- *Intrapersonal Playability* or Personal Playability: This refers to the individual outlook, perceptions and feelings that the video game produces in each player when they play, and as such has a high subjective value.
- *Interpersonal Playability* or Social Playability: This refers to the feelings and perceptions of users, and the group awareness that arise when a game is played in company, be it in a competitive, cooperative or collaborative way.

The overall Playability of a video game, then, is the total sum of values across all attributes in the different Facets of Playability. It is crucial to optimise Playability across the different facets in order to guarantee the best PX. Figure 2 represents the different Facets of Playability and their relationship to common elements of a video game.

In this paper, we propose a graphical representation of the PX. The overall playability, which characterises the PX, can be analysed thanks to Facets of Playability and can be represented using the *Surfaces of Playability*.

If we imagine that every facet is a vertex of a polygon, playability can be represented as the area covering the 'n-sided polygon', the area representing the impact of the PX at different dimensions or points of view for analysing the experience. Moreover, by focusing on the attributes that characterise playability, we can obtain a similar representation called the Surface of Playability. Thus, for the overall playability of the facets, we are able to represent the percentage area involved and which attribute (or facet) has greater influence on the UX.

A representation such as this offers us the possibility to analyse and visualise playability in a simple and direct way, as well as to compare various analyses and/or assessments in order to identify common patterns between different video game genres.

We conclude that the *Global Playability* of a video game, $P(g)$ can be defined as the weighted sum, Ω , of the playability of each facet, with each facet of playability affected by a weight factor, μ, depending on the type of game design or genre (Equation (1)). Furthermore, in this work, we present a tool for the automatic representation of the Surfaces to realise Playability and PX reports in the evaluation development stage. Some examples of weight factors and how to apply them in the video game analysis can be found in González Sánchez (2011).

$$P(g) = \Omega(\mathrm{I}\mu_I, \mathrm{M}\mu_M, \Lambda\mu_\Lambda, \mathrm{P}\mu_P, \Theta\mu_\Theta, \Phi\mu_\Phi).^4 \qquad (1)$$

Figure 3 shows examples of areas that represent the experience based on the facets and attributes of Playability. It is worth noting that thanks to this type of representation we are able to analyse, for example, how certain types of video games are inadequate (in terms of playability) because they focus more on a didactic multimedia unit in which, due to repetitive challenges and boring game mechanics, the concept of play is clearly secondary. *Playability Model* and *Playability Representations* (together known as *Playability Framework*) offer designers and developers the possibility to analyse and evaluate the degree of entertainment and effectiveness in the experience of different video game genres, in order to improve the final UX. In the following section, we show practical examples and experiments of how to use the Playability Framework to evaluate and improve the PX in different video games. In addition, to have the optimal

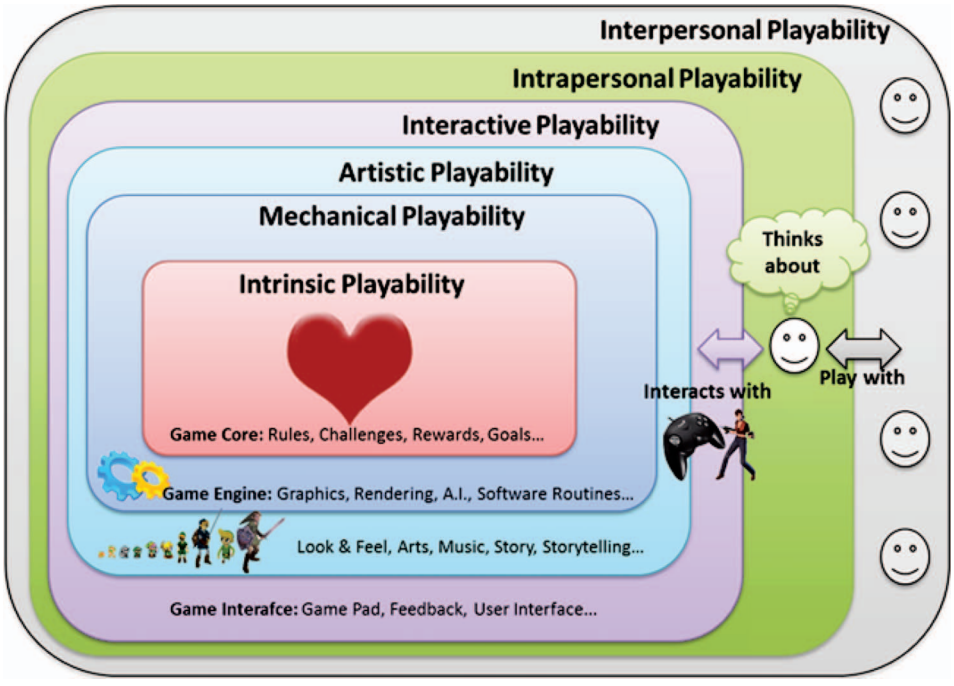

Figure 2. Facets of Playability and elements of a video game.

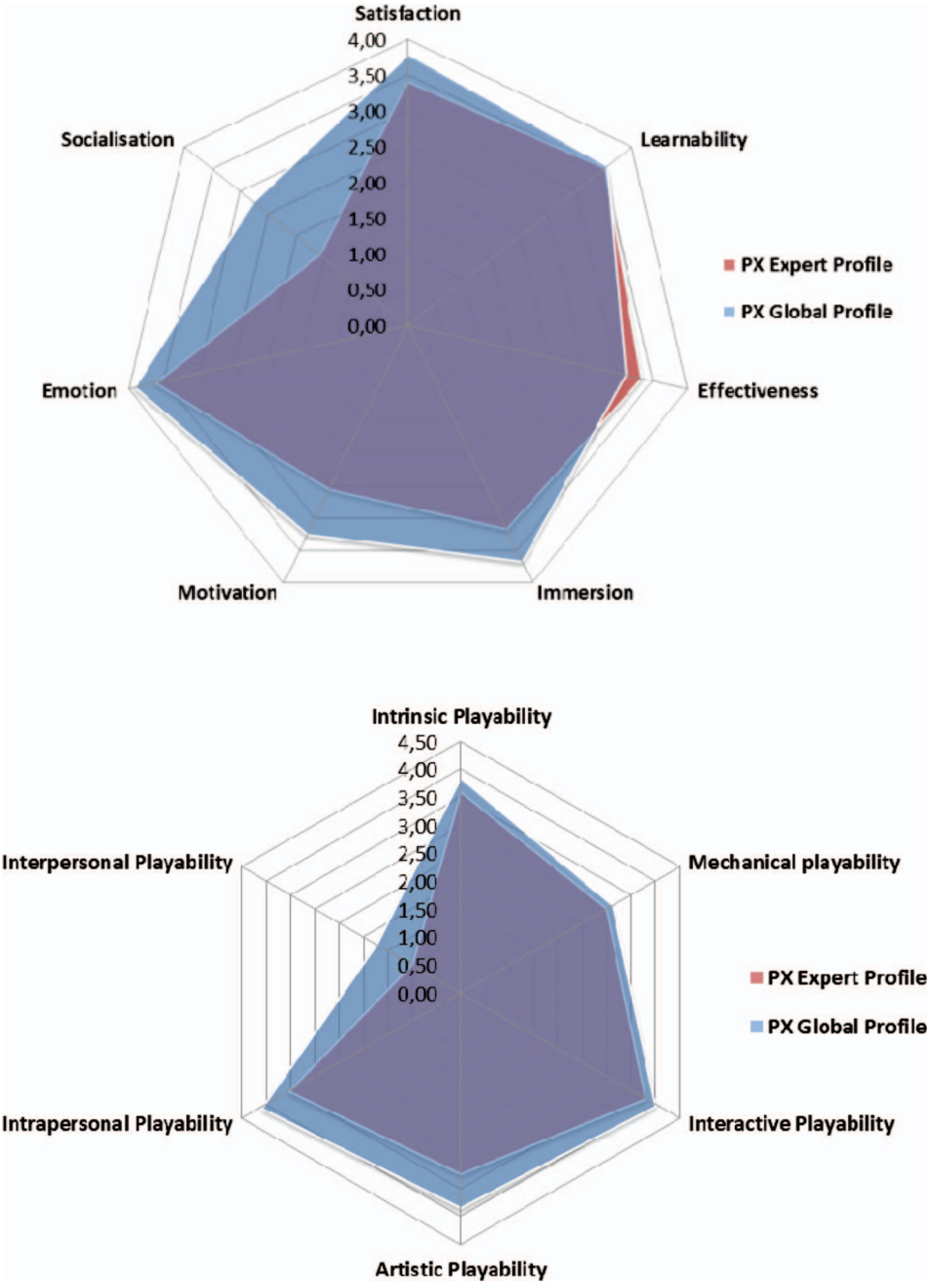

Figure 3. Using surfaces of playability to compare 'expert' profile (red) and 'casual' profile (blue) for the UX evaluation of 'Disaster: Day of Crisis': surface based on attributes of playability (up) and Facets (down).

weight factors could be difficult due to the different video game genres and player profiles that interact with video games. Sometimes, the weight may be ignored initially, and sometimes can be used according to the results of previous studies or from existing databases. Nevertheless, the main benefit of this framework is that it provides a guide, a point of view to perform measurements with specific video game elements, thanks to Facets of Playability. Also, we can visualise information of each attribute/facet and its experience impact thanks to Surface of Playability.

4. Using playability to evaluate the PX in video games

In this section, we described the *Playability Model* which characterises the PX in video games. In this section, we look at how it can be applied at different phases of the video game development process,

allowing us to obtain more complete information about the full experience of the player and possible UX improvements. We also focus on two specific aspects that we consider fundamental to achieve good playability: the video game design (requirements elicitation and analysis) and testing PX (validation and verification requirements, and playability evaluation).

4.1. Using playability to obtain and test playable requirements

The Playability Model and the analysis of process-oriented facets provide us with a mechanism for playability requirements analysis, looking at which attributes may be affected and which elements of a video game can lead to a better UX. To analyse the elements, which are critical in the analysis phase, we propose using the ontology referenced throughout this work (González Sánchez and Gutiérrez 2010).

It is therefore advisable to include a list of requirements guided by facets, where each attribute of playability and its related game element is analysed in order to obtain a positive UX. Techniques of requirements analysis and specification can be accomplished within the Game Design Document (GDD) (Rollings and Morris 2003). We also recommend using a numerical or level rating system to help prioritise requirements established at different phases of the video game development, or to be included in the prototypes used to evaluate PX following a User Centred Development (see Table 2). This process allows us to meet the basic requirements for achieving a positive experience thanks to the complete specification of the playable requirements in the GDD.

4.2. Applying the playability model in UX video game evaluation phase

The Playability Model offers a mechanism for the evaluation (validation, verification) of the PX and acts as a complementary alternative to the traditional tests performed by the video game industry professionals. Many of the playability analyses carried out within the QA Team[5] focus on functional aspects of the game, rather than on the non-functional PX. Moreover, we note that given the nature of their work, a QA Tester possesses some skills that make him/her perceive the game differently to other players.

For this reason, the Playability Model presented serves as an assessment tool to ascertain which attributes have a greater influence on the UX, graphically representing the experience through the Surface of Playability. We are also able to build a relationship with the elements that most influence the game through the Facets of Playability, allowing the impact of different game elements on the overall experience to be detected.

As illustration of how to evaluate and analyse the UX in video games, in this work, we present an example of a real evaluation of a commercial video game based on our proposal of the Playability Model. It is important to remark the importance of the Playability Model because the model unifies different

Table 2. Example of how to use the Playability Model to classify some playable requirements for a GDD.

Facets	Attribute	Requirement to be achieved	Associated VG element	Priority level
Playability interactive	Satisfaction	Using the stylus and game pad	Challenges and input sub-system	H
	Learnability	Tutorials in the initial level	Rules and mechanics	M
	Effectiveness	Using the stylus as a pencil	Input system	M
	Immersion	Using two screens: Cause and Consequence	Output sub-system	H
	Motivation	Hearts, coins and visual and audible rewards	Rewards	H
	Emotion	Facial expressions and line colours	User interface	L
	Socialisation	Using the microphone and sending messages	Output sub-system	L
Mechanical playability	Satisfaction	No delay or sync appreciation	Rendering engine	H
	Learnability	Adjusting the number of concepts according to difficulty	A.I. engine	M
	Effectiveness	Surround areas for tactile detection of each pictogram	Game engine	H
	Immersion	Stylus recognition and voice controls	I/O control system	H
	Motivation	Minimum load times among phases	Game engine	M
	Emotion	Fade effects to change the phase in 'mysterious way'	Game engine	H
	Socialisation	Using WI-FI for multiplayer	I/O control system	M

metrics or studies in order to characterise and analyse the PX. The objectives of this example are:

- Analyse in a quantitative/qualitative way the PX using the Playability Model.
- Test the effect of certain elements of a video game in the overall PX.
- Identify problems that may cause a negative PX.
- Complete the functional assessment and objectives of QA systems with non-functional evaluations that are closer to the experience for each player profile.
- Offer reports that provide complete information of every aspect of the PX.

4.2.1. *Context for the UX video game evaluation*

Following, we describe the context for evaluating the PX and how to analyse the playability of a particular video game.

The evaluation of playability was carried out in a laboratory, in order to observe how people actually play the game. The evaluation method is mainly classified as a mixed method, using heuristic evaluation techniques (by expert players) and user test with questionnaires and observation techniques based on metrics. Also, we incorporate observation techniques due to we are working in the context of the UX, so it is important to obtain all information about different player profiles so that the results are representative of the context of actual video game use (information about the experience). To evaluate the PX with a given video game, we proposed five sessions of play lasting 20 min, using normal levels of difficulty throughout the game. Metrics can be used during the test evaluation. The evaluation process is guided by Facets of Playability, and it is possible to relate the elements of a video game to playability attributes. The evaluation was divided into four stages and the results are structured following Common Industry Format for Usability (CIF) ISO/IEC 9126–4 (Appendix F):

- *Pre-Test*: Questionnaires and a short test to obtain information about player profiles. These were completed with emotional information and multicultural background influences. The main objective is to analyse the participants.
- *Test:* Experimental performing of task. We collected information with metrics about PX while users played a video game. Metrics are based on the Playability Framework.
- *Post-Test*: We gave players different questionnaires or heuristics, according to the user profile. These questionnaires and heuristics were guided by the Facets of Playability.
- *Reports:* We obtained a number of reports about the PX with information about which playability attributes had more influence, or which type of elements were more valued by the players. We perform data analysis, data scoring and different representation of the PX and playability.

As a support tool for the evaluation process, we used Playability and Hedonic Evaluation Tool (PHET) (González Sánchez 2011, González Sánchez *et al*. 2011b). This tool allows creation and evaluation of playability heuristics and questionnaires, graphical analysis of the data, and provides ways to evaluate and measure the PX with different metrics. PHET offers the possibility of applying different questionnaires and relates them to attributes of playability, following the facets and adding new questions and metrics. PHET has different modes of use. The tool's first two modes of operation are designed for experts responsible for the evaluation, allowing them to personalise questionnaires metrics, factors and describe the profiles of the video games and platforms to be analysed. The evaluation mode is also important so that the evaluator can choose the appropriate test for the 'test-users'. However, to obtain the maximum information about UX, we used two different player profiles: 'expert' (a person who is a good player, knows the game platform perfectly and is comfortable with difficult game challenges) and 'casual' (a person who plays infrequently and looks for quick entertainment). For our evaluation, we require information of all game players, not only experienced ones, in order to analyse the experience of all the possible player profiles and identify which elements of the video game affect the results.

The evaluation process should be performed using a list of questions (list of heuristics for 'expert' evaluator or list of question for 'casual' testers), aiming to investigate the degree of each attribute of playability in order to obtain a measurement of the PX. Some of the questions are based on validated heuristics/questionnaires works (Desurvire *et al*. 2004, Korhonen 2006, Korhonen and Koivisto 2007, Pinelle *et al*. 2008, Desurvire and Wiberg 2009), which are readapted/extended to follow the facets, and associate them with the Playability Model and the ontology of the video game elements. The questions and heuristics are designed to extract information about the pragmatic and hedonic PX dimensions. In Table 3, we present some characteristic questions guided by Facets that are used by PHET to evaluate the UX. The questionnaires are derived from these heuristics and adapted to the player profile.

4.2.2. *Evaluation tests and UX results*

In the previous section, we described the tools and mechanisms for evaluating the PX using playability

Table 3. Examples of some questions guided by Facets used by PHET.

Facets of Playability	Evaluation heuristics
Intrinsic playability	The game mechanics are fun and interesting for the player
	The game can be replayed by offering new challenges
	The game can be played without using the help manual
	The game has different difficulty levels and/or a difficulty system that adapts the challenges to the player's skills
	The game provides a means to facilitate the memorisation of the items displayed and assimilate their subsequent use
Mechanical playability	The game engine satisfies the player and exploits the full platform resources
	The game provides a balanced IA system to readapt the challenges to the player actions
	The game offers dynamic context-sensitive help for overcoming a specific challenge.
	The game offers correction mechanisms for the player control and actions in the game
	The graphics and textures are rendered without appreciable errors for the players
Artistic playability	The game story and narrative are pleasing to the player
	The game story catches the player's attention and the important elements are remarked during the play time
	The game music is consistent with the challenges and immerses the player in the game dynamic
	The visual elements (graphics, sprites, animations, etc.) are attractive to the player
	The game does not reveal future story events that may affect the player's interest
Interactive playability	The game control system, menus and dialogs are attractive and enjoyable for the player
	Learning and memorisation of game controls and IU are performed in a pleasant and entertaining way for the user
	The controls and menus follow the standards of the game genre
	The game interface is not intrusive for players.
	The game controls and menus can be customised and mapped according to the player's preferences
Interpersonal Playability	The time spent on game and amusement obtained is high
	The percentage of unblocked game is high
	The amusement caused by the challenge is high
	The actions and precision of movements for overcoming the challenges are high
	The number of attempts at every challenge is generally low
Intrapersonal Playability	New game objectives, rules and challenges are easily identified with several players playing the game
	The 'full' game story is complete for all players or can be completed by every player sharing the story events
	The social interaction among other players or characters in the new dynamic of play is attractive to the player
	There are game elements to identify the identity of each player within the virtual world
	The social game controls with other players or characters differ little from the individual game system

techniques. We now explain in more detail the complete evaluation experiment and results.

4.2.2.1. Pre-test. In the *Pre-Test*, we were able collect information about the profile of participants using multimedia questionnaires (images, pictures, music, videos, etc.). It is a part of the Participant Analysis. The analysis of the users who participated in the test is performed in terms of demographics, game experience and preferences. Relevant characteristics are: (1) gender: male of female; (2) age: state the chronological age of the participants; (3) education: state the number of years of completed formal education; (4) game experience: describe relevant background, such us how much experience the user has with a video game or a game platform; and (5) product experience: indicate the type and duration of any prior experience with the product or similar products.

The experiment involved the participation of 27 student volunteers from the Master Software Development and other degree course students at the School of Computer and Telecommunications Engineering in Granada, Spain. The most significant results about the profile of the participants were as follows:

- The majority were male (≈80%) between 20 and 25 years old (90%).
- Considered to be casual players (play approximately 5 h per week and have experience of only one games console or a mobile phone).
- Had knowledge of different gaming platforms, including a mobile and a desktop platform (≈90%).
- 20% of the students had a 'higher level' as players (they are referred to as 'hardcore' players), playing more than 5 h per week and with experience of more than one games console,

such as Ps3 and Wii, laptops and mobile phones. These players acted as video game 'experts' in the evaluation process.

We worked with the students to analyse and profile the heuristic and questionnaires evaluation of playability and its impact on each attribute and property of the Playability Model, and to identify elements of the game that have more impact on the overall UX.

4.2.2.2. Test. During the *Test*, users played the video game. The game chosen as an evaluation example was 'Disaster: Day of Crisis' for Wii, developed by Monolith Soft in 2008. We chose the Wii platform due to its high degree of interaction and the influence this has on UX (Pre-Test reaffirm this results).

The experiment sessions were carried out in the usability laboratory. It was five sessions of 20 min of duration each one. In the different sessions, test players played different game levels in a 'normal' difficulty level. A log of every session was recording to corroborate the results and to analyse future improvements in the video game, with interview and the results of the questionnaires. Users' facial and body expression was recorded with three cameras. To analyse their experience, we applied different guidelines, such as De Lera and Garreta-Domingo (2007), Nacke and Lindley (2009a) and van den Hoogen *et al*. (2008). These techniques offer information about emotional interaction process with a low cost of processing. Also, we utilised different 'Quality in Use' metrics following the ideas of González Sánchez *et al*. (2009c), Canossa and Drachen (2009) and Tychsen and Canossa (2008). Some examples of metrics and the results obtained are shown in Table 4.

We analyse with game metrics and observation techniques how the player played the video game and the experiences of the interactive process.[6] Some interesting results about Test process are revealed:

- At the beginning of the adventure, players were uncertain, looking around to capture all screen elements (≈78%).
- With the arrival of challenges at the climax of the level, stress increased, provoking surprise and agitation in the player (lifting of the eyebrows, 94%). The stress caused by the challenges increased the player's concentration. Players pressed the pad quicker and more violently (≈89%) than at the beginning of the game.
- At the climax of the level, two types of strategies were detected: a defence strategy, which was adopted by 100% of female users and 25% of men, who were intimidated by the game enemies and natural catastrophes. However, 75% of male users preferred a direct and violent confrontation. In both cases, the degree of immersion was high, a factor which was indicated by the increase of the movement of the game control and how the player presses the buttons with more violence, even when the action was over.
- Finally, stress became satisfaction, which was expressed as a slight smile or slight gasp (≈82%).

4.2.2.3. Post-test. At the *Post-Test*, we used informal interviews and questionnaires to obtain information about the PX. As we have indicated, the evaluation process was performed using a list of questions, with the aim of investigating the degree of each attribute of

Table 4. Results of some playability metrics during the Test applied to the level 5 of the game.

Metric	Expert player				Casual player			
	Avg	SD	Max	Min	Avg	SD	Max	Min
Effectiveness								
Number of items collected in the level	5.86	2.12	8	3	4.56	1.8	6	1
Immersion								
Number of direct challenges in the level	12.8	1.15	14	10	9.5	2.24	13	5
Time to reach the main goal in a level	5.43	1.92	7.5	4.85	6.87	1.62	9.3	5.4
Number of goals/time of the levels	0.29	0.12	0.5	0.2	0.26	0.05	0.3	0.2
Motivation								
Time to reach the final goal of the level	6.52	1.8	8.09	5.7	7.52	1.68	10.83	6.25
Time to pass level	7.2	2.24	10.12	6.75	7.75	2.12	11.5	6.5
Number of items used in the level	5.49	1.54	6	3	4.29	0.76	5	3
Learnability								
Number the personalised options used	3.71	1.11	5	2	2.5	0.54	3	1
Number of attempts in the level	1.67	0.88	3.4	1.1	2.3	0.99	4.1	1.45
Socialisation								
Time to pass the level/number of attempts	4.31	2.33	6.14	2.18	3.37	2.14	4.48	2.80
Number of people saved in the level	8.00	1.50	9.00	6.00	6.00	2.00	8.00	6.00

playability in order to obtain a measurement of the PX. The process is guided by Facets of Playability. We opted to use a scale of numerical values between 0 (negative) and 5 (positive) to present the results, considering that, together with the reports made by PHET, this would give us enough information to evaluate experience. In Table 3, we presented some characteristic questions guided by Facets that are used by PHET to evaluate the UX. These questions are inspired in some questionnaires and heuristics from representative works on the area (see Järvien *et al*. 2002, Korhonen and Koivisto 2007, Pinelle *et al*. 2008, Desurvire and Wiberg 2009, Calvillo-Gomez *et al*. 2010, Poels *et al*. 2010, González Sánchez 2011) and readapted following 'The Playability Framework' (attributes to measure and guided by facets). The summary of scores describing the global PX can be seen in Table 5.

4.2.2.4. Reports and results. We also obtained a number of *Reports* about the PX with information about which playability attributes had more influence, or which type of elements were more valued by the players. Using the Surfaces of Playability, we are able to represent the results of the Playability Evaluation that is incorporated into the PHET report module (Figure 3). To generate the Surface, we use the standard co-efficient for this kind of genre that internally PHET use to generate this report according to Equation (1). Another interesting aspect of the playability framework is the ability to compare results of UX between different games, the same versions of games for different platforms or between different player profiles. Figure 3 shows the differences between the 'expert' and 'casual' experience. These representations allow us to discern the similarities and differences between the analysed experiences.

The evaluation results of experience automatically obtained by PHET (Tables 4 and 5; Figure 3) were completed using additional information obtained through observation and the application of metrics and questionnaires/interviews and other suggestions from players. This permitted us to evaluate the playability of a particular video game in depth and analyse the UX obtained.

Following our experiment, the analysis of UX can be summarised in these main points:

- One of the clearest results was that 'casual' players were happiest with the game. This was reflected in the high values scored for the interactive facet, and ease of use of game controller (see Section 3.1.2).
- The positive result for 'casual' players meant a negative experience for 'expert' players, due to the excessive ease of play. The challenges and goals, which contribute to the learning process, were too simple, decreasing emotion and motivation during the play. This result was corroborated by low degree of 'personal' playability in 'expert' profiles.
- Concerning the artistic level, the results showed how the game's graphical quality was acceptable by all players, but the 'expert' players preferred the higher graphic quality of other platforms, such as Xbox360 and PS3, and considered the aesthetic aspect of the game to be a little disappointing.
- Most differences in the results can be seen in the social factor. 'Casual' players were satisfied by sharing the game with other players, increasing a positive experience that complements the infrequency of social challenges with other characters in the game process. For the 'expert' player, the result was a negative social experience, contributing to lower levels of motivation. This was due to the fact that 'expert players' normally play video games in an online setting and are accustomed to interacting in much more complex social challenges.
- For both 'casual' and 'expert' players, the game provided high values of excitement (high degree of emotion) and immersion due to the controls and game dynamics (slightly lower for 'expert' player because they are used to playing these kinds of games on a more frequent basis).

Table 5. Global playability results from the PX Evaluation of 'Disaster Day of Crisis'.

Facet	Satisfaction	Learnability	Effectiveness	Immersion	Motivation	Emotion	Socialisation	Avg	Std. Dev
Intrinsic	3.9	4.43	3.5	4.29	3.63	4.2	3	3.85	0.51
Mechanical	3.71	2.33	3	3.5	3	4	2.33	3.12	0.65
Interactive	4.67	4.23	4	4.45	3.5	4.57	2.67	4.01	0.71
Artistic	4	4.67	3	4.2	3.67	4	3.33	3.84	0.56
Intrapersonal	4.43	4	3.6	4.45	3.75	4.75	3.67	4.09	0.45
Interpersonal	2	1.67	1.67	1.2	2	2	1.6	1.73	0.30
Average	3.79	3.56	3.13	3.68	3.26	3.92	2.77	3.44	0.41
SD	0.94	1.24	0.81	1.27	0.67	0.99	0.74	0.90	

- The effectiveness of the game was high, the players had fun, but it is difficult to extrapolate global results due to the limited number of sessions. An increased number of sessions may have given different results. However, expert players achieved more challengers and explored in deep the different options of the Gameplay mechanics/dynamics (see Table 4).
- It can clearly be seen that the game should provide different difficulty levels for the expert player. More complex challenges could thus improve the motivation attribute.
- In both player profiles, the most valued video game element is the game platform. This result was obtained thanks to the integrity rules and structural equations of the conceptual model used in PHET (González Sánchez 2011), where each element of the game can be analysed, evaluating its impact on all playability attributes guided by facets.

5. Conclusions and future work:

This work reflects the importance of having a framework to quantitatively and qualitatively analyse the experience that players have with video games, as well as how to analyse both the value of this experience and which elements of a game are the most/least playable. Understanding and evaluating the UX in video games is important for developing more efficient and successful products in terms of entertainment.

We have presented a unified model for the analysis of UX in a video game context. The main focus is on the characterisation of playability thanks to a series of attributes and properties to measure it. Playability attributes can describe the experience from the UX point of view (pragmatic and hedonic).

Furthermore, we have proposed a mechanism for analysing experience based on different points of view called 'Facets of Playability'. This provides us with a guided procedure to evaluate the attributes of playability on the different elements of a video game. To represent the results of PX, we have used a graphic representation called 'Surface of Playability'. The facets also allow us to relate playability attributes to the different elements of a video game in order to analyse the impact that each element may have on overall playability or on a specific facet.

We have demonstrated how the Playability Framework can be used in the different phases of the video game development process, especially for the analysis and design phase where we can analyse, classify and evaluate the most important playable requirements or obtain information about the player's preference for each playability attribute. In the evaluation phase, it is possible to use PHET as a support tool in the evaluation of PX in video games. Therefore, it helps us to describe, for example, the requirements specification or test playable prototypes or the overall PX. It means the experiences related to: emotions, aesthetic, social, be immersed, quality of play, game elements, time spent playing and so on.

We have also provided a practical example of UX evaluation of the UX in commercial video games using different evaluation methods guided by Playability facets and PHET with our proposal based on CIF. We used different player profiles to obtain more complete and accurate information about the PX. The results were reported graphically using the Surface of Playability. The practical experiment shows the benefits of a framework to measure in detail which elements of a video game promote a positive experience and which elements generate a negative experience, analysing the attributes of playability. A framework such as this also enables the comparison of PX between different player profiles or similar video games. Through a practical example, we have demonstrated the importance of this kind of evaluation for the development of a product that can incite better experiences or specific experiences depending on the target market. With this framework, we can deduce what attribute has more impact on the final experience and how to solve the different problems related with the interactive experience in the next interaction of a player-prototype development process.

This model completes, unifies and improves the alternatives in the area of UX in video games and offers the possibility of measuring the degree of final experience of players based on measurable and quantifiable attributes and properties and helps to evaluate and understand the impact of the elements of a video game on UX across diverse player profiles thanks to a Playability Facets. Furthermore, Playability Model can be easily related to quality standards, so Playability can be used as an indicator of the quality of game.

As future work, we propose the creation of a design methodology for players following the steps of User Centred Design (ISO 13407) and the ideas discussed in this paper. The main objective of this methodology is to improve the final product experience in 'player centred' video game development. We are currently working on the different development phases, especially on the requirement analysis and evaluation of experience. We are working on including the use of agile methodology to help us iterate on different game prototypes, in order to evaluate and improve playable prototypes and readapt the experience to the possible changes in requirements and preferences which can occur when the players test the game.

In addition, we aim to evaluate the 'forms' of the surface action of playability to find common patterns and to analyse weight factors in the UX that help us to promote a specific experience in predefined player profiles. With these results, we plan to offer design patterns and guidelines to assist designers to enhance the overall experience when players play a video game.

Also, we are working in evaluate and analyse the hedonic information of the interaction process in order to obtain more information about the player experience. Playability Model offers the possibility of analyses of the pragmatic and hedonic experience, but it is interesting to have more details and deepen about the players' emotions. So, we are currently adapting different emotional and cross-cultural evaluation techniques and dimensions to characterise the interaction experience in more detail and extract rich patterns. We hope that this will help game developers improve the final PX. With this idea, we extended the actual Quality in Use standard (ISO 2011) to the video game field, showing the Playability as quality factor of the experience (González Sánchez *et al*. 2009c). In addition, we are currently working on the incorporation of more questions based on validated questionnaires, metrics and heuristics for the UX community (i.e. GEQ, CEGEQ and others) and readapting them following the playability attributes and facets presented in this work.

Finally, we are currently applying Playability and Accessibility Techniques to characterise the PX in educational and sanitary rehabilitation video games with collaborative activities. In this kind of game, a positive experience leads to greater efficiency as a didactic tool, in accordance with the philosophy of 'Learning by playing, playing to learn' (González Sánchez *et al*. 2008, Ibrahim *et al*. 2011).

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Notes

1. Some profiles for video game players:
   - *Casual Gamer*: a player whose time or interest in playing games is limited or do not spend much time playing more involved games.
   - *Mid-core gamer*: a player with a wide range of interests and enthusiast toward creative and diverse games, but without the amount of time spent and sense of competition of a hardcore gamer.
   - *Hardcore gamers* prefer to take significant time and practice on games, and tend to play more involved games that require larger amounts of time to complete or master.
2. Quick Time Events: In video games, a Quick Time Event (QTE) is a method of context-sensitive gameplay in which the player performs actions on the control device shortly after the appearance of an on-screen prompt. It allows for limited control of the game character during cut scenes or cinematic sequences in the game.
3. In this work, we emphasise the three basic levels of the conceptual model of video games:
   - The *Game Mechanic* is formed by the set of elements that characterise and differentiate one game from another: rules, challenges, rewards, goals, and so on.
   - The *Game Engine* refers to a series of software routines that allow the execution of all elements of the game.
   - The *Game Interface* is the set of elements that are responsible for the interaction between players and video game.
4. Intrinsic P. (I), Mechanical P. (M), Artistic P. (Λ), Personal P. (P), Social P (Θ) and Interactive P (Φ).
5. QA or Game testing, a subset of game development, is a software testing process for the quality control of video games and the experience.
6. It is not the main objective of this point to emphasise how to make this observation analysis with video games. The objective is to use the result as complementation information of the experience for the Playability Framework.

References

Axelrod, L. and Hone, K.S., 2006. Affectemes and allaffects: a novel approach to coding user emotional expression during interactive experiences. *Behaviour & Information Technology*, 25 (2), 159–173.

Bach, C. and Scapin, D.L., 2010. Comparing inspections and user testing for the evaluation of virtual environments. *International Journal of Human–Computer Interaction*, 26 (8), 786–824.

Barr, P., Noble, J., and Biddle, R., 2007. Video game values: human–computer interaction and games. *Interacting with Computers*, 19 (2), 180–195.

Bernhaupt, R., 2010. *Evaluating user experience in games: concepts and methods* (Human–Computer Interaction Series). Berlin/Heidelberg, Germany: Springer-Verlag.

Bernhaupt, R., *et al*., 2008. Evaluating user experiences in games. *In*: *CHI '08 extended abstracts on Human factors in computing systems*, 5–10 April 2008, Florence, ItalyNew York: ACM.

Bialoskorski, L.S.S., Westerink, J.H.D.M., and van den Broek, E.L., 2010. Experiencing affective interactive art. *International Journal of Arts and Technology*, 3 (4), 341–356.

Bierre, K., *et al*., 2005. Game not over: accessibility issues in video games [online]. Available from: http://people.dsv.su.se/~thomasw/wp-content/uploads/2007/12/hcii2005_gac.pdf [Accessed 15 May 2011].

Björk, S., Lundgren, S., and Holopainen, J., 2003. Game design patterns. *In*: Copier, M. & Raessens, J. (Eds.) 2003. Level Up – Proceedings of Digital Games Research Conference 2003, Utrecht, The Netherlands, 4–6 November 2003.

Byun, S. and Byun, S.-E., 2011. Exploring perceptions toward biometric technology in service encounters: a comparison of current users and potential adopters. *Behaviour & Information Technology* [online], 1–14. doi: 10.1080/0144929X.2011.553741. Available from: http://www.tandfonline.com/doi/abs/10.1080/0144929X.2011.553741#preview (iFirst view).

Calvillo-Gámez, E.H., Cairns, P., and Cox, A.L., 2010. Digital games, the aftermath: qualitative insights into post game experiences. *In*: R. Bernhaupt, ed. *Evaluating user experiences in games*. Berlin: Springer, 47–72.

Canossa, A. and Drachen, A., 2009. Play-personas: behaviours and belief systems in user-centred game design. *Human-computer interaction – INTERACT 2009, Lecture notes in computer science*, 24–28 August, Uppsala, Sweden. Vol. 5727. Berlin, Heidelberg: Springer, 510–523. ISBN 978-3-642-03657-6.

Chen, M., *et al*., 2005. Creating cross-cultural appeal in digital games: issues in localization and user testing. *In*: *Presentation at the 52nd annual conference for the Society for Technical Communication (STC)* [online]. Available from: http://markdangerchen.net/pubs/Game_Slides_final3.ppt [Accessed 11 February 2011].

Clanton, C., 1998. An interpreted demonstration of computer game design. *In*: *CHI 98 conference summary on Human factors in computing systems (CHI '98)*, New York, NY: ACM, 1–2.

Crawford, C., 1984. *The art of computer game design*. Berkeley, CA: McGraw-Hill/Osborne Media.

Csikszentmihalyi, M., 1990. *Flow: the psychology of optimal experience*. New York: Harper and Row.

de Kort, Y.A.W., IJsselsteijn, W.A., and Poels, K., 2007. Digital games as social presence technology: development of the Social Presence in Gaming Questionnaire. *In*: *PRESENCE 2007 Proceedings*, 25–27 October, Barcelona, Spain, 195–203.

De Lera, E. and Garreta-Domingo, M., 2007. Ten emotion heuristics: guidelines for assessing the user's affective dimension easily and cost-effectively. *In*: C.O. Thomas and S. Corina, eds. *Proceedings of the 21st British HCI Group annual conference on HCI 2007: HCI (BCS HCI 2007)*, 3–7 September 2007. Vol. 2. Lancaster: University of Lancaster. ISBN 978-1-902505-95-4.

Desurvire, H. and Wiberg, C., 2009. Game usability heuristics (PLAY) for evaluating and designing better games: the next iteration. *In*: A. Ozok and P. Zaphiris, eds. *Proceedings of the 3d international conference on online communities and social computing: held as Part of HCI International 2009 (OCSC '09)*. Berlin. Heidelberg: Springer-Verlag, 557–566.

Desurvire, H., *et al*., 2004. Using heuristics to evaluate the playability of games. *In*: *CHI '04 extended abstracts on Human factors in computing systems (CHI EA '04)*, New York, NY: ACM, 1509–1512.

Dix, A., 2004. *Human computer interaction*. Englewood Cliffs, NJ: Prentice Hall.

Druin, A., 2002. The role of children in the design of new technology. *Behavior and Information Technology*, 21 (1), 1–25.

Federoff, M., 2002. *Heuristics and usability guidelines for the creation and evaluation of fun in video games*. (Master of Science Thesis). Indiana University.

Gajadhar, B., de Kort, Y., and IJsselsteijn, W., 2008. Influence of social setting on player experience of digital games. *In*: *CHI '08 extended abstracts on Human factors in computing systems (CHI EA '08)*, *CHI '08 CHI conference on human factors in computing systems*, 5–10 April, Florence, Italy. New York, NY: ACM.

González Sánchez, J.L., *et al*., 2008. Playability: the secret of the educational videogame design. *In*: T. Conolly and M. Stansfield, eds. *2nd European conference on games bases learning (ECGBL 2008)*, 16–17 October, Barcelona, Spain. Paisley: University of West Scotland, 147–156. ISBN: 978-1-906638-19-1.

González Sánchez, J.L., Padilla Zea, N., and Gutiérrez Vela, F.L., 2009a. From usability to playability: introduction to player-centred video game development process. *In:* M. Kurosu, ed. *Proceedings of the 1st international conference on human centered design: held as part of HCI international 2009 (HCD 09)*. Berlin, Heidelberg: Springer-Verlag, 65–74.

González Sánchez, J.L., Padilla Zea, N., and Gutiérrez Vela, F.L., 2009b. Playability: how to identify the player experience in a video game. *In:* T. Gross, *et al*., eds. *Proceedings of the 12th IFIP TC 13 international conference on human-computer interaction: Part I (INTERACT '09)*. Berlin, Heidelberg: Springer-Verlag, 356–359.

González Sánchez, J.L., 2011. Jugabilidad y Videojuegos Análisis y Diseño de la Experiencia del Jugador en Sistemas Interactivos de Ocio Electrónico – Playability and Video Games. Analysis and Design of User Experience on Interactive and Entertainment Systems. Ed. Académica Española, Lambert Academic Publishing GmbH & Co KG, Saarbrücken.

González Sánchez, J.L., *et al*., 2009c. Playability as extension of quality in use in video games. *In: 2nd international workshop on the interplay between usability evaluation and software development (I-USED.)* Vol. 490. Published in CEUR Workshop, 37–43. ISSN 1613-0073.

González Sánchez, J.L., and Gutiérrez, F.L., 2010. *Video game's elements ontology: a video game's elements ontology to analyze the player's experience* [online]. Protege Stanford Ontology Library. Available from: http://protegewiki.stanford.edu/wiki/Protege_Ontology_Library

González Sánchez, J.L., Gil Iranzo, R.M., and Gutiérrez Vela, F.L., 2011. Enriching evaluation in video games. *In*: P. Campos *et al*., eds. *Proceedings of the 13th IFIP TC 13 international conference on human-computer interaction (INTERACT'11)*. Vol. Part IV. Berlin, Heidelberg: Springer-Verlag, 519–522.

Grammenos, D., Savidis, A., and Stephanidis, C., 2009. Designing universally accessible games. *Computer Entertain*, 7 (1), 1–29.

Hewett, T., 1992. *ACM SIGCHI curricula for human–computer interaction*. New York: ACM, Technical Report.

Ibrahim, A., Gutiérrez Vela, F.L., and González Sánchez, J.L., 2011. Playability design pattern in educational video game. *In: 5th European conference on games bases learning (ECGBL 2011)*, 20–21 October, Athens, Greece, 282–290. ISBN 978-1-907282-18-8.

Idoughi, F., Seffah, A., and Kolski, C., 2011. Adding user experience into the interactive service design loop: a persona-based approach. *Behaviour & Information Technology*, 31 (3), 287–303.

IGDA, 2004. Accessibility in games: motivations and approaches [online]. Available from: http://www.igda.org/accessibility/ [Accessed 20 November 2011].

IJsselsteijn, W.A., de Kort, Y.A.W., Poels, K., Jurgelionis, A., and Bellotti, F., 2007. Characterising and measuring user experiences in digital games. *In*: *Proceedings of the International Conference on Advances in Computer Entertainment Technology (ACE 2007)*, 13–15 June 2007, Salzburg, Austria, Salzburg.

Isbister, K. and Schaffer, N., 2008. *Game usability: advice from the experts for advancing the player experience*. San Francisco: Morgan Kaufmann.

ISO/IEC 9241-11, 1998. *Ergonomic requirements for office work with visual display terminals (VDTs) – Part 11: guidance on usability*. Geneva: ISO.

ISO/IEC 9241-210, 2010. *Ergonomics of human–system interaction – Part 210: human centred design for interactive systems. Clausule 2.15*. Geneva: ISO.

ISO/IEC 25010, 2011. *Software product Quality Requirements and Evaluation (SQuaRE). Software product quality and system quality in use models*. Geneva: ISO.

ISO/TR, 18529, 2000. *Human-centred lifecycle process descriptions*. Geneva: ISO.

Jagne, J. and Smith-Atakan, A., 2006. Cross-cultural interface design strategy. *Universal Access in the Information Society*, 5 (3), 299–305.

Järvien, A., *et al*., 2002. Communication and community in digital entertainment services. *Hypermedia Laboratory Net*2. [online]. Available from: http://tampub.uta.fi/tup/951–44–5432–4.pdf [Accessed 7 February 2011].

Korhonen, H.K., 2006. Playability heuristics for mobile games. *In*: *DIMEA07 second international conference on digital interactive media in entertainment and arts*, 19–21 September, Perth, Australia. New York, NY: ACM.

Korhonen, H. and Koivisto, E.M.I., 2007. Playability heuristics for mobile multi-player games. *In*: *DIMEA07 second international conference on digital interactive media in entertainment and arts*, 19–21 September, Perth, Australia.

Lai-Chong Law, E. and Sun, X., 2012. Evaluating user experience of adaptive digital educational games with activity theory. *International Journal of Human-Computer Studies* [online]. *ISSN*, 1071–5819. doi: 10.1016/j.ijhcs.2012.01.007.

Law, E. and van Schaik, P., 2010. Modelling user experience – an agenda for research and practice. *Interacting with Computers*, 22, 313–322.

Law, E., *et al*., 2009. Understanding, scoping and defining user experience: a survey approach. *In*: *CHI '09 CHI conference on human factors in computing systems*, 4–9 April, Boston, MA. New York, NY: ACM.

Lazzaro, M., 2008. Game usability: advice from the experts for advancing the player experience. *In*: K. Isbister and N. Schaffer, eds. Morgan Kaufmann, 315–345.

Lepper, M.R. and Malone, T.W., 1987. Intrinsic motivation and instructional effectives in computer-based education. *In:* R.E. Snow and M.J. Farr, eds. *Aptitude, learning, and instruction: III. Conative and affective process analysis*. Hillsdale, NJ: Erlbaum, 255–286.

Lindley, S.E. and Monk, A.F., 2011. Measuring social behaviour as an indicator of experience. *Behaviour & Information Technology*, 1–18. doi: 10.1080/0144929X.2011.582148.

Mandryck, R.L., Inkpen, K.M., and Calvert, T.W., 2006. Using psychophysiological techniques to measure user experience with entertainment technologies. *Behaviour & Information Technology*, 25 (2), 141–158.

Medialt, 2008. *Guidelines for developing accessible games* [online]. Available from: http://gameaccess.medialt.no/guide.php [Accessed 3 September 2011].

Nacke, L.E., *et al*., 2009a. *Playability and player experience research* [online]. West London, 1–5. Available from: http://www.digra.org/dl/display_html?chid = 09287.44170.pdf [Accessed 1 August 2012].

Nacke, L., *et al*., 2009b. *In*: B. Atkins, H. Kenn, and T. Krzywinska, eds. *Breaking new ground: innovation in games, play, practice and theory: proceedings of the 2009 digital games research association conference*, 1 September–4 September, Brunel University, West London, 1–5.

Nacke, L.E., *et al*., Biofeedback game design: using direct and indirect physiological control to enhance game interaction. *In*: *Proceedings of the 2011 annual conference on Human factors in computing systems (CHI '11)*, *CHI '11 CHI conference on human factors in computing systems*, 7–12 May, Vancouver, BC, Canada. New York, NY: ACM.

Nielsen, J., 1993. *Usability engineering*. Boston, MA: Academic Press. ISBN 0-12-518405-0 (hardcover), 0-12-518406-9 (softcover).

Nielsen, J. and Landauer, T.K., 1993. A mathematical model of the finding of usability problems. *In*: *INTERCHI 93 – conference on human factors in computing systems*, 24–29 April, Amsterdam, the Netherlands.

Nielsen, J. and Mack, R., 1994. *Usability inspection methods*. New York: John Wiley.

NNG, 2003. *User experience – our definition* [online]. Nielsen Norman Group Ed. Available from: http://www.nngroup.com/about/userexperience.html [Accessed 5 June 2010].

Nokia, 2010. *Game design and user experience* [online]. Available from: http://library.forum.nokia.com/index.jsp?topic=/Design_and_User_Experience_Library/GUID–21B5CE2C–7141–41CF-A669–2006502C151E. html [Accessed 7 May 2011].

Norman, D.A., 2004. *Emotional design: why we love (or hate) everyday things*. New York: Basic Books.

Olsen, T., Procci, K., and Bowers, C., 2011. Serious games usability testing: how to ensure proper usability, playability, and effectiveness. *In*: A. Iin Marcus, ed. *Design, user experience, and usability. theory, methods, tools and practice*. Lecture Notes in Computer Science 6770. Berlin/Heidelberg: Springer, 625–634.

Ott, M. and Pozzi, F., 2011. Digital games as creativity enablers for children. *Behaviour & Information Technology*, 1–9 (iFirst Article). doi:10.1080/0144929X.2010. 526148.

Padilla Zea, N., *et al*., 2009Design of educational multiplayer videogames: a vision from collaborative learning. *Advances in Engineering Software*, 40 (12), 1251–1260.

Pinelle, D., Wong, N., and Stach, T., 2008. Heuristic evaluation for games: usability principles for video game design. *In*: *CHI '08 CHI conference on human factors in computing systems,* 5–10 April, Florence, Italy. New York, NY, USA: ACM.

Poels, K., *et al*., 2009. Digital games, the aftermath. Qualitative insights into Post game experiences. *In:* R. Bernhaupt, ed. *Evaluating user experiences in games*. Berlin: Springer.

Poels, K., *et al*., 2010. Digital games, the aftermath: qualitative insights into post game experiences. *In*: R. Bernhaupt, ed. *Evaluating user experiences in games*. Berlin: Springer, 149–165.

Rollings, A. and Adams, E., 2003. *Andrew Rollings and Ernest Adams on game design*. Indianapolis, IN: New Riders Games.

Rollings, A. and Morris, D., 2003. *Game architecture and design*. Indianapolis, IN: New Riders Games.

Saito, A., 2008. Gamenics and its potential. *In*: K. Isbister and N. Schaffer, eds. *Game usability: advice from the experts for advancing the player experience*. San Francisco: Morgan Kaufmann, 357–381.

Sauer, J. and Sonderegger, A., 2010. The influence of product aesthetics and user state in usability testing. *Behaviour & Information Technology*, 30 (6), 787–796.

Shin, D.-H., Biocca, F., and Choo, H., 2011. Exploring the user experience of three dimensional virtual learning environments. *Behaviour & Information Technology*, 1–12 (iFiirst Article). Available from: http://www.tandfonline.com/doi/abs/10.1080/0144929X.2011.606334

Shneiderman, B., 2000. Universal usability. *Communications of the ACM*, 43, 84–91.

Shneiderman, B., 2004. Designing for fun: how can we design user interfaces to be more fun? *Interactions*, 11 (5), 48–50.

Swink, S., 2007. *Game feel: the secret ingredient* [online]. Gamasutra: Available from: http://www.gamasutra.com/view/feature/2322/game_feel_the_secret_ingredient.php [Accessed 14 December 2010].

Tychsen, A. and Canossa, A., 2008. Defining personas in games using metrics. *In*: *FuturePlay 2008 (FuturePlay '08) academic games conference,* 3–5 November, Toronto, Ontario, Canada. New York, NY: ACM.

Usability-First, 2009. *Playability definition* [online]. Available from: http://www.usabilityfirst.com/glossary/playability/ [Accessed 11 November 2010].

van den Broek, E.L., 2010. Beyond biometrics. *Procedia Computer Science*, 1 (1), 2505–2513.

van den Hoogen, W.M., IJsselsteijn, W.A., and de Kort, Y.A.W., 2008. Exploring behavioral expressions of player experience in digital games. *In*: *Proceedings of the workshop on facial and bodily expression for control and adaptation of games ECAG 2008*, September, Enschede, The Netherlands.

Voida, A. and Greenberg, S., 2011. Console gaming across generations: exploring intergenerational interactions in collocated console gaming. *Universal Access in the Information Society*, 11 (1), 1–12. doi: 10.1007/s10209–011–0232–1.

Westin, T., *et al*., 2011Advances in game accessibility from 2005 to 2010. *In*: C. Stephanidis, ed. *Universal access in human-computer interaction. Users diversity*. Lecture Notes in Computer Science 6766. Berlin/Heidelberg: Springer, 400–409.

Ye, J. and Ye, D., 2004. *HCI and game design: from a practitioner's point of view* [online]. Available from: http://www.ye-brothers.com/documents/HCIGAMEDESIGN.pdf [Accessed 17 November 2010].

Yuan, B., Folmer, E., and Harris, F., 2010. Game accessibility: a survey. *Universal Access in the Information Society*, 10, 81–100.

Zaphiris, P. and Siang Ang, C., 2007. HCI issues in computer games. *Interacting with Computers*, 19 (2), 135–139.