

PONTIFICIA UNIVERSIDAD CATÓLICA DE VALPARAÍSO
FACULTAD DE INGENIERÍA
ESCUELA DE INGENIERÍA INFORMÁTICA

**Developing a Set of Playability/Player Experience Heuristics for
the Evaluation of 3D First Person Shooters**

Michele Marco De Conti Rivara

Guide Professor: **Alexandru Cristian Rusu**

Graduate Thesis
Magíster en Ingeniería Informática

December 2017

Abstract

The video game industry moves millions of dollars worldwide, with thousands of games released every year for every platform. For this reason, is of the utmost importance for developers to assure that their video games will satisfy the expectations of the players and keep their attention in this big but bloated market, which is not an easy task considering the highly subjectivity of the matter. In order to this games to be easily played and enjoyed by gamers, in other words to improve the Playability and the Player Experience, this document propose the creation of a set of Playability/Player Experience heuristics for First Person Shooter games, in order to help game developers to detect potential problems that can hinder the enjoyment of players with their games.

Keywords: Playability Heuristics, Player Experience, First-Person Shooter Games, Gameplay.

Contents

Abstract	i
1 Introduction	1
1.1 Bibliographic Discussion	1
2 Problem Definition	3
2.1 Definition of Objectives	3
2.1.1 General Objectives	3
2.1.2 Specific Objectives	3
2.2 Research Methodology	3
2.3 Work Scope	4
2.4 Work Methodology	4
2.5 Work Performed for Stage	6
2.6 Work Plan	8
3 Literature Review	9
3.1 Games and Video games	9
3.2 First Person Shooters	9
3.2.1 Singleplayer interaction	11
3.2.2 Multiplayer interaction	11
3.3 Playability	12
3.4 User and Player Experience	13
3.4.1 Psychological Models of Player Experience	14
3.4.2 Integrative Models of Player Experience	15
3.5 Core Elements of the Gaming Experience	15
3.5.1 Video game	15
3.5.2 Puppetry	15
3.6 Heuristic evaluation	17
3.7 Genres in Usability Evaluations	20
4 Attributes and Properties Selection	22
4.1 Omitted Attributes and Properties	22
4.2 Attributes, properties and characteristics considered	23
4.2.1 FPS characteristics and common problems	23
4.2.2 Playability model	24
4.2.3 Player Experience Model	24
4.2.4 Usability	25

5 Validation of the New Set of Heuristics	29
5.1 Heuristic Evaluation	29
5.1.1 Selection of the Existing set of Heuristics	29
5.1.2 Selection of Experts and Test Groups	29
5.1.3 Selection of the Case Study	30
5.1.4 Evaluation of the effectiveness of the new set	30
5.2 Expert Judgement	31
5.3 Results of the Heuristic Evaluation	32
5.3.1 Control Group	32
5.3.2 Experimental Group	32
5.3.3 Analysis of the Heuristic Evaluation data	33
5.3.4 Effectiveness of heuristics in terms of number of usability problems identified	34
5.3.5 Effectiveness of heuristics in terms of number of specific usability problems identified .	35
5.3.6 Effectiveness of heuristics in terms of usability problems identified as more severe . .	36
5.3.7 Effectiveness of heuristics in terms of usability problems identified as more critical ..	37
5.4 Results of the Expert Judgement	39
5.5 Comments of Experts	39
6 Refinement of the New Set of Heuristics	41
6.1 Changes on Heuristic N°2 Aesthetic and Minimalist Design	41
6.2 Changes to Heuristic N°3 Error Prevention	41
6.3 Changes to heuristic Heuristic N°4 Controls and Responsiveness	41
6.4 Changes to heuristic N°8 Structure of Objectives and Pacing of the Game	41
6.5 Changes to Heuristic N°12 Emotional Stimuli	41
6.6 Changes to Heuristic N°13 Socialization and Character Relationships	42
7 Definition and Formalisation of the New Set of Heuristics	43
8 Conclusions and Future Work	58
Appendices	62
A Sets of heuristics	62
B Lists of Playability/Player Experience problems found with the new and control sets of heuristics	69

List of Figures

1	Investigation approaches according to Hérnandez Sampieri, R. 2006	4
2	Summary of the work performed on each stage of the work methodology	7
3	Metal Slug, a 2D shooter with a side-view perspective.	10
4	3D first and third person perspectives, GTA V on the left and Battlefield 1 on the right.	10
5	Playability model: attributes and properties which characterise the Player Experience, according to González et al.	13
6	The CEGE model of Calvillo-Gámezetal et al: The figure depicts the relationships among observable (rectangles) and latent (circles) variables.	17
7	Number of problems found by each heuristic set	33
8	Correct and wrong associations between problem and heuristics of each set	34
9	Effectiveness of heuristics in terms of number of specific usability problems identified	36
10	Effectiveness of heuristics in terms of the severity of the problems identified	37
11	Effectiveness of heuristics in terms of the criticality of the problems identified	38
12	Visual hit indicator in <i>Overwatch</i> . From top to bottom: (1) single hit, (2) headshot and (3) kill, which are accompanied with their respective sound effects.	44
13	Typical view of the player during gameplay on <i>Overwatch</i> : (1) Time and objective status, (2) Player chat, (3) Current character and hit points, (4) Ultimate ability status, (5) Recent kills, (6) Ammunition and abilities status, (7) Teammates, (8) Current objective.	44
14	One example of an unintended state on <i>Battlefield 1</i>	46
15	One example of an error message on <i>Overwatch</i>	46
16	On <i>Battlefield 1</i> , in long distance shots the player must compensate the effect of gravity and the relative movement of the target.	48
17	Quick options to commonly used commands on <i>Overwatch</i>	49
18	Voice chat in <i>Overwatch</i>	50
19	<i>Metro Last Light</i> shooting range.	52
20	Training modes in <i>Overwatch</i>	52
21	Contextual help in <i>Overwatch</i>	53
22	An example of how the visual enhances and complements the world presented in <i>Metro Last Light</i>	54
23	Summary of the player's performance after a match on <i>Overwatch</i>	55
24	Different play styles offered in <i>Metro Last Light</i>	56
25	Difficulty selection on <i>Metro Last Light</i>	57

List of Tables

1	Standard template to specify usability heuristics, by Daniela Quiñones and Cristian Rusu	6
2	Work plan	8
3	Nielsen's Heuristics	17
4	Game Heuristics according to Pinelle et al.	18
5	Heuristics of Korhonen and Koivisto for evaluating mobile games	19
6	List of usability problems found in video games according to Pinelle et al.	20
7	Omitted Attributes and Properties	22
8	Omitted aspects from the Player Experience Model	23
9	Comparative table	26
10	Preliminary set of heuristics	28
11	Comparison of the first iteration of the new set and the Game Heuristics [24] of Pinelle et al.	29
12	Table included in the Expert Judgement to assert the Utility of the heuristics, according to Daniela Quiñones and Cristian Rusu [27]	31
13	Total of problems found with the control heuristics, with the number of correct and wrong associations	32
14	Total of problems found with the new heuristics, with the number of correct and wrong associations	33
15	Summary of the problems found in each category	34
16	Effectiveness of heuristics in terms of number of specific usability problems identified	35
17	Effectiveness of heuristics in terms of the severity of the problems identified	36
18	Rating scales of usability problems detected	37
19	Effectiveness of heuristics in terms of the criticality of the problems identified	38
20	Average of the results of the Expert Judgement, in yellow the averages lower than 3.7	39
21	Summary of the comments of experts	40
22	Heuristic N°1 Feedback and Game Status	43
23	Heuristic N°2 Aesthetic and Minimalist Design	45
24	Heuristic N°3 Prevention and Recognizement of Errors	45
25	Heuristic N°4 Controls and Responsiveness	47
26	Heuristic N°5 Collision and Physics Consistency	47
27	Heuristic N°6 Artificial Intelligence Engagement	48
28	Heuristic N°7 Multiplayer Communication	49
29	Heuristic N°8 Structure of Objectives and Pacing of the Game	51
30	Heuristic N°9 Help and Tutorials	51
31	Heuristic N°10 World Aesthetics, Rules and Mechanics Consistency	53
32	Heuristic N°11 Curiosity, Challenges and Rewards	54
33	Heuristic N°12 Socialization and Character Relationships	55

34	Heuristic N°13 Game Fairness and Difficulty	56
35	Heuristics for Evaluating Playability (HEP), developed by Desurvire et al.	63
36	Examples of some questions guided by Facets used by PHET, developed by González et al. .	64
37	Play Heuristics, category 1: Game Play, by H. Desurvire and C. Wiberg	65
38	Play Heuristics, Category 2: Coolness/Entertainment/Humor/Emotional Immersion by H. Desurvire and C. Wiberg	66
39	Play Heuristics, Category 3: Usability & Game Mechanics by H. Desurvire and C. Wiberg .	67
40	Core Elements of the Gaming Experience Questionnaire (CEGEQ),Calvillo-Gámezetal et al .	68
41	List of Playability/Player Experience problems found with the new set of heuristics	70
42	List of Playability/Player Experience problems found with the new set of heuristics (cont.) .	71
43	List of Playability/Player Experience problems found with the control set of heuristics	72

1 Introduction

The first video game can be traced back to the "Cathode ray tube Amusement Device", the earliest known interactive electronic game that was patented in 1947, and ever since they only have grown in relevance. Now is the third largest segment in the U.S. entertainment market, behind broadcast and cable TV, generating estimated sales of 74 billion US dollars worldwide. This industry is divided in multiple platforms, from the traditional home and portable consoles, the PC (Personal Computer) to the behemoth that the mobile game industry has become, with around the 24% of the whole games market.

As this document focus primarily in 3D First Person Shooters (FPS) games, is important to note the relevance of this genre in the video game industry as a whole. According to the 2017 essential facts [12] about the computer and video game industry of the Entertainment Software Association (ESA), 27.5% of all games units sold in the United States are shooters, and 9 out 20 of the top selling games titles in North America correspond only to this specific genre of games. But even with this profitable market, the amount of games published every year is growing even faster; for example on Steam, the biggest digital distribution platform, almost 40% of the games offered on this platform were released only in 2016, according to the data of Steam Spy [4], a website dedicated to estimate the number of sales of software titles and other statistics about Steam.

In other words, we have a growing but bloated market and a relevant genre of video game, under this context, game developers need a way to assure that their game will be enjoyed by the final users, the players. This is something difficult to accomplish as this "enjoyment" is tied to the concepts of Playability and player Experience that are highly subjective matters that depends in great measure on the personal tastes of the player, making it difficult to even define them formally, let alone evaluate. Another problem comes with the vast differences between game genres, for example a traditional Role-Playing Game (RPG) is completely different to a (FPS) in terms of gameplay, visual design, interface, objectives, controls, character interactions and depth of the plot, to name a few differences, making this task even more challenging.

Finally, as these discrepancies in game genres have an impact on the kind of problems that can hinder the ease by which a game can be played (in other words, damage the Playability) [25], this documents will focus on the sub-genre of the 3D FPS games to develop an specific set of Playability heuristics to help in the detection of problems that can hinder the Playability of the game and worsen the Player Experience (PX). In order to this set to be effective and efficient on the evaluation on this kind of interactive application, the methodology to develop usability/user experience heuristic proposed by Daniela Quiñones and Cristian Rusu [27] will be followed to develop it.

1.1 Bibliographic Discussion

In order to understand the problem definition, this section presents a brief explanation of several key concepts. The in-depth review and analysis of such concepts is located in section 3.

- **Game:** A game is a structured form of play, usually undertaken for enjoyment and not by biological need. Games raises from the human capacity to pretend and the need to play they have nontrivial goals

and are constrained by a set of rules [11].

- **Video game:** Is an electronic game that involves the interaction of a user (player) with a user interface to generate visual feedback on a video device such as a TV screen or computer monitor. These games are played in different platforms, such as handheld and home consoles, computers and other mobile devices such as phones. The input devices used for games, the game controller, varies across platforms; from gamepads joysticks, mouse and keyboard or touch screens, among other examples.
- **3D First Person Shooter (FPS) games:** A 3D FPS is a game where the player takes actions at a distance in a first person perspective, using primarily ranged weapons. Usually presents a recognisable world and set of physic and collision systems that resemble reality. Depending on the game, can offer singleplayer or multiplayer experience (or both) [11].
- **Usability:** According the ISO [19], is "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use". This product can be a software, a tool, a machine or anything a human interacts with.
- **User Experience (UX):** Includes the usability but makes reference to the emotions and attitudes of the user before, during, and after using an interactive product, system or service. Is a multidisciplinary and highly subjective topic, many authors have defined models trying to formalise this term, but there is not a complete agreement about it.
- **Playability:** Is derived from the Usability, and focuses on the interaction between a player and game. This became so relevant that this separated and more specific definition appeared, which is a measure of either the ease with which a video game may be played, or of the overall quality of its gameplay.
- **Player Experience (PX):** PX is to Playability as UX is to Usability, if Playability measures the ease to play a game, PX involves the cognitions, emotions and physical activity while playing a game and immediately afterwards.

2 Problem Definition

2.1 Definition of Objectives

In this section the main objective of this research is presented alongside the specific objectives, which define the principal milestones that will help the main goal.

2.1.1 General Objectives

- Develop a set of Playability/Player Experience heuristics for 3D First Person Shooter games.

2.1.2 Specific Objectives

- Perform a conceptual research about video games, 3D First Person Shooter games, Playability and Player Experience.
- Formulate a set of Playability Heuristics that allows the easy and efficient evaluation of 3D First Person Shooter games.
- Validate the set of Playability/Player Experience heuristics.

2.2 Research Methodology

According to the work of Hernández Sampieri [20] there are two approaches on investigation: Quantitative and qualitative, the first one uses the recollection and analysis of data to answer the investigation questions, and test the previously formulated hypothesis, trusts the numerical measurement, counting and frequently, the use of statistics. The second one is frequently based in data recollection methods that does not rely on numerical measurement like descriptions and observations. These two approaches use five similar steps:

1. They observe and evaluate the phenomena
2. They establish assumptions or ideas as a consequence of the observation and evaluation done
3. They demonstrate the degree in which the ideas or assumptions have basis
4. They check those ideas or assumptions based on the test or analysis
5. They propose new observations and evaluations to clarify, modify and base the assumptions and ideas; and even generate new ones

As stated in previous sections, the evaluation of Playability and Game Experience is highly subjective, dependant on the human nature and difficult to measure in a precise and numeric way. For this reasons the most adequate methodology for this document is the qualitative approach.

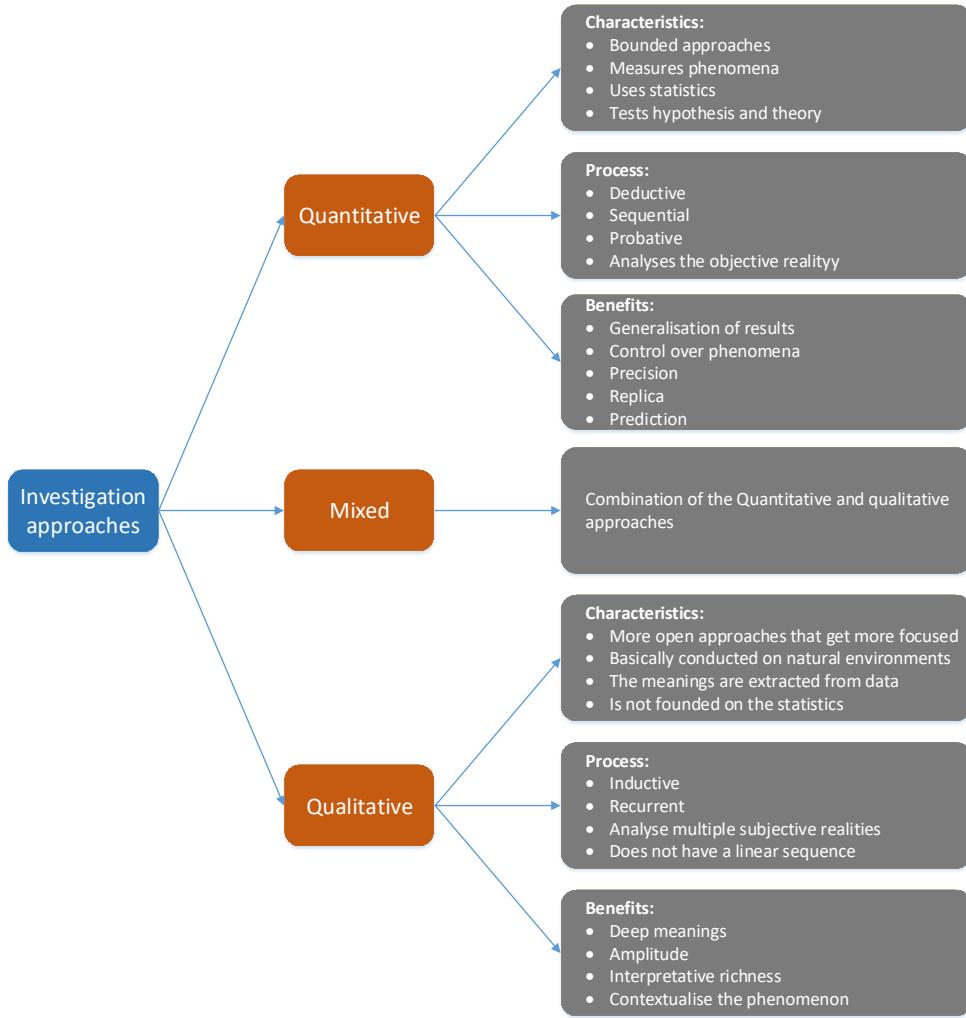


Figure 1: Investigation approaches according to Hernández Sampieri, R. 2006

2.3 Work Scope

In a first stage it will be descriptive, based on an exploratory study with the objective to examine and investigate the subject of this document in order to specify its characteristics, properties and features from which theories may later be developed to explain the observations. In a second stage this document will be correlative which has for objective the evaluation of the relationship between two or more concepts, or variables. This stage pretends to evaluate the grade of correlation between different variables and tries to predict one based in the behaviour of another. So far this document has only focused in the descriptive stage, while in future instalments, the correlative stage will be incorporated.

2.4 Work Methodology

To achieve the objectives of this document, the methodology to develop usability/user experience heuristics for specific domains proposed by Daniela Quiñones and Cristian Rusu [27] is used. This methodology is

divided in the following eight stages:

1. **Exploratory stage:** In the first stage, a review of the current literature is conducted, in order to collect information about the specific application domain for which the new set of heuristic will be created, the characteristics of such application, and about the existing usability heuristics.
2. **Experimental stage:** The second stage consists in the performing of experiments such as heuristics evaluations, usability tests, interviews or surveys. This step is optional, but highly recommended as the information identified by the experiments will be useful in the step 3 and 4.
3. **Descriptive stage:** The third stage consist in the selection and highlighting of the most important topics of all the collected information in the previous stage, in order to formalise the main concepts associated with the research. Is also decided what features classifications and/or definitions will be used in relation to the specific application.
4. **Correlational stage:** In the fourth stage the characteristics that the heuristic for the specific application should have are defined. Is recommended to base this in the Existing sets of usability/UX heuristics and on the experiments performed in step 2. In this step is suggested to determine whether heuristics will be classified into categories, define how many heuristics will be developed and what element will include (as id, definition, explanation, examples, checklists, or other element that is considered useful).
5. **Selection stage:** In the fifth stage, the existing sets of usability/UX heuristics collected in Step are selected of discarded according to its usefulness to evaluate the specific application. In this step it is possible to identify very similar or equal heuristics obtained from different sets, in this case, only one heuristic must be chosen complementing the information of necessary.
6. **Specification stage:** In the sixth stage, the new set of usability/UX heuristics is formally specified using a standard template. If the heuristics were grouped into categories, they must be specified in a coherent order. The template proposed by the authors is shown in table 1. They also recommended that at least the items marked with a “*” would be used to specify the heuristics. Other items are optional.
7. **Validation stage:** in this seventh stage, the effectiveness and efficiency of the usability/UX set of heuristics is validated through experiments, like heuristic evaluation, expert judgement and user test.
8. **Refinement stage:** The last stage consists in the refinement of the new set, based on the feedback obtained from the validation stage. The problems detected and the changes that should be made needs to be documented, and based on the results, more iterations of some stages may be needed, until an effective set of heuristics is achieved. In the current state of this investigation, and due to resources and time constraints, only one iteration was performed.

Table 1: Standard template to specify usability heuristics, by Daniela Quiñones and Cristian Rusu.

*	ID	Heuristic's identifier.
*	Priority	Numerical value that identifies how important the heuristic is to evaluate a specific aspect or feature. The value can be: (1) Useful. This heuristic further improves the usability of the application. (2) Important. The heuristic evaluates a relevant aspect of the application. (3) Critical. The heuristic evaluates a crucial aspect of the application.
*	Name	Heuristic' name
*	Definition	A brief but concise heuristic' definition
*	Explanation	Heuristic' detailed explanation. Detail which aspects of the application are covered. It may also include what typical usability problems are evaluated.
	Examples	Examples of heuristic's violation and compliance.
	Benefits	Expected usability benefits, when the heuristic is accomplished.
	Problems	Anticipated problems of heuristic misunderstanding, when performing heuristic evaluations.
	Checklist	Items or criteria associated with heuristics. Each item or criterion consists of a short and precise affirmation that identifies the compliance of heuristics in different aspects of an application evaluated in a heuristic evaluation.

2.5 Work Performed for Stage

This section is presented to make clearer what activities were performed in each stage of the work methodology [27]. Figure 2 is also presented as a visual representation of this process.

1. **Exploratory stage:** In the first stage, a review of the current literature was performed. First the key concepts, namely Usability, Playability, User and Player Experience (UX and PX respectively), games, video games and first person shooters (FPS), were investigated. Detecting the most important aspects of each one. Also four existing Playability heuristics sets were examined and one Playability and PX model were selected in order to extract the most relevant aspects in the context of FPS games.
2. **Experimental stage:** According to the work methodology, this stage has an optional nature, and for time and resources constraints, it was decided to not perform any experiments.
3. **Descriptive stage:** In this stage, from all the key concepts investigated in the exploratory stage, the most important and relevant aspects of each one (considering the context of the investigation) were highlighted in order to make a list of 16 characteristics and attributes the new set should comply. Is worth noting that some aspects of the models were discarded as they were not considered important for the FPS game context.
4. **Correlational stage:** In this stage, the 16 characteristics and attributes highlighted in the previous one were correlated to the existing heuristic sets. Every characteristic could be completely covered, partially covered or not covered by the existing set. There were 4 characteristics that were not covered by any existing set.
5. **Selection stage:** In the selection stage, if the characteristic was covered in the previous stage, by one or more existing set, the definition was used as a foundation for the new one, if the aspects was partially

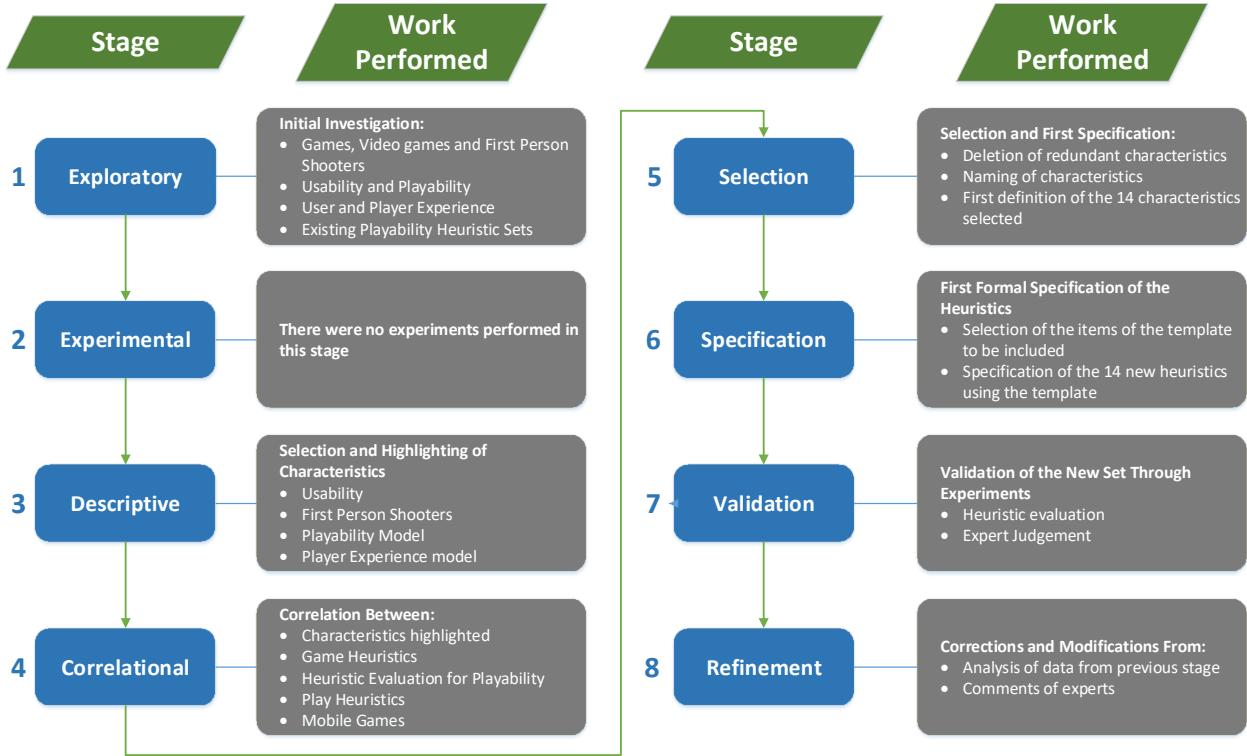


Figure 2: Summary of the work performed on each stage of the work methodology

covered, more changes were performed to adapt it to the new context. If none of the existing sets, covered the characteristic, a completely new heuristic was developed. Redundancy was also eliminated resulting in 14 prototypes of heuristics (from 16 total of characteristics) which were provided a first and more standard definition and name.

6. **Specification stage:** In this stage, the first formal definition was performed, using the template provided by the work methodology (see table 1), were each of the 14 heuristics were given an ID, priority, name, definition, explanation and examples.
7. **Validation stage:** In this stage, and using the aid of experts, the new set of heuristic is evaluated in terms of its efficacy and efficiency. A heuristic evaluation was performed, were the new set was compared to an existing and generic one, in terms of number and severity of the problems found, and the ratio of correct and wrong assignations between problem and heuristic. Also the feedback of the experts was queried in the form of a survey that took into account four dimensions of each heuristic: Utility, clarity, ease of use and necessity of examples. Finally, some comments from the experts were also collected. Is worth noting that in this stage, the new set obtained very good results compared to the existing, and more generic set.
8. **Refinement stage:** In the final stage, and using the information gathered from the validation stage, many changes were made: One heuristic was entirely removed (for being considered too hard to evaluate), the definition and name of one heuristic was modified. Various corrections, clarifications and

redaction changes were performed, and finally new examples were added, resulting in the modification of six different heuristics.

2.6 Work Plan

In table 2, the schedule using during the development of this document is presented. As can be appreciated there is a correlation between the steps of the Work Methodology and the ones presented in the work plan. Is worth noting that due time constraints, the experimental stage will be omitted. One final consideration is that the last two stages are iterative, so multiple revision can be performed until the heuristic set reach the desired level of quality, but in the end due to the time and resources constraints, only one iteration was done.

Table 2: Work plan

Activity/Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Thesis seminar	x	x	x	x	x					
Problem formulation	x	x								
Problem description	x	x								
Literature review	x	x	x							
State of the art		x	x							
Feature clasification and definition of FPS				x						
Specification of the characteristics of the heuristic set				x						
Heuristic selection and discard				x	x					
Heuristic specification					x					
Thesis project						x	x	x	x	x
Selection and specification of the validation test(s)						x				
Validation of the heuristic set							x	x	x	
Refinement of the heuristic set								x	x	
Conclusions									x	x

3 Literature Review

In this section definitions of crucial concepts are deeply explained and related work currently available in the literature is presented in an extensive way.

3.1 Games and Video games

According to the Fundamentals of Game Design [11], games arise from the human desire to *play* which is a wide category of nonessential, and usually recreational, human activities that are often socially significant as well. They also involve the human capacity to *pretend*, the mental ability to establish a notional reality that the pretender knows is different from the real world and that the pretender can create, abandon, or change at will. Both concepts have been extensively studied as cultural and physiological phenomena. A third element of games are *goals*, an arbitrary, nontrivial objective the participant(s) try to achieve in accordance with a set of *rules*.

Video games are a subset of the universe of all games. A video game is a game mediated by a computer, which can be the modest handheld console to a huge electronic play environment at a theme park. The computer enables video games to borrow entertainment techniques from other media such as books, films, karaoke, and so on. Unlike conventional games, video games do not require written *rules*, is the machine that implements and enforces them for the players. The computer also determines when the player reaches the *goal*, it adjudicates victory and defeat if those concepts are programmed into the game. Video games allow players to try things without having to read the rules to see whether the game permits it, letting players to *pretend* more easily and become much more deeply immersed in the game, allowing them to see it not as a temporary artificial environment with arbitrary rules, but as an alternate universe of which the player is a part of.

3.2 First Person Shooters

To establish what is a First Person Shooter (FPS) game, the definition will be also based on the Fundamentals of Game Design [11] of Ernest Adams. Firstly, shooters are a sub-genre of the Action Games where the player takes actions at a distance, using primarily ranged weapons. For this reason, the player must pay attention to the surroundings of the avatar and the potential target or targets. Inside the shooter genre there are two broad categories, the 2D and 3D shooters, in the first one the game takes place in an environment viewed from either a top-down or side-view perspective and they usually lack of realistic physics in pursuit of a fast paced gameplay (see section 3.3). The second and more broadly known, the 3D shooters, are in general at the cutting edge of what game hardware is capable of in terms of graphics, and usually are more realistic than 2D shooters. Presents at least recognisable worlds, where the game tends to simulate the behaviour of real world physics; gravity has an effect on gameplay, sound diminishes with distance, objects cast shadows and collisions are modelled with a fair level of accuracy, even some games present deformable environments, where the landscape changes dynamically to the explosions and other events.

3D shooters can use two different perspectives, firstly the first person perspective, where the visual field



Figure 3: Metal Slug, a 2D shooter with a side-view perspective.

of the actions of the player corresponds to the "eyes" of the avatar, enabling the player to see clearly the targets without the avatar blocking part of the screen but limiting the arc of vision of the player from a 120 horizontal degrees in the real life to about 30 degrees in a monitor with 4:3 aspect ratio. This has important gameplay implications that are out of the focus of this investigation as is too intrinsically tied to the existent hardware. Secondly the third person perspective, where the player can see his avatar on-screen, usually from a viewpoint in which the camera is behind and somewhat above the avatar. Finally, some games can use both kinds of perspectives according to the weapon, for example a third person shooter using a first person perspective when the characters use the scope or sight of a rifle. Finally, there are another sub categories of shooters like Rail-shooters, Tactical Shooters, Survival horror and Arena games but this categorisation is too granular for the purposes of this document, where the focus will be 3D FPS games.



Figure 4: 3D first and third person perspectives, GTA V on the left and Battlefield 1 on the right.

Another important characteristic of these games that is discussed in the following sections is the interaction (or the lack of) with other human players. Is worth noting that this division is not excluding as many FPS have a single player campaign and a multiplayer mode such as *Call of Duty* or many *Battlefield* games.

3.2.1 Singleplayer interaction

Many games focus in the singleplayer experience where the player makes progress in the game alone (or with the help of computer-controlled characters). For this reason this kind of experiences rely more heavily on the narrative to draw the player into and to create a sense of investment and immersion, this last topic was deeply investigated by Emily Brown [14]. Another consideration is that in order to generate this immersion, the player needs to interact with interesting and meaningful Non Player Characters (NPC) and with the world presented. In general the singleplayer campaign of traditional FPS tend to be relatively short, for example according to the data of How long to beat [1], in average a game of the Call of Duty or Battlefield franchises have a length of 7 to 12 hours . In the case of the *Mass Andromeda* franchise (a FPS game with many RPG mechanics) have an average length of 30 to 60 hours. This contrasts with a traditional open-world RPG's like *Dragon Age* where depending on the play-style of the gamer can take up to 130 hours, or in the case of *The Legend of Zelda: Breath of the Wild* can take up to 160 hours.

3.2.2 Multiplayer interaction

Many FPS offers a Multiplayer mode or focus exclusively on it, this experience is based on human-human interaction for its conflict, so they don't rely so heavily in the narrative to drive the experience of the player. The interaction may be cooperative, where a group of human-controlled characters must cooperate to achieve an objective against a computer-controlled enemy, or can be completely human to human, where there are not Artificial Intelligence involved. Even if multiplayer games like *Counter strike* have a narrative to set the conflict (where a team of counter-terrorist need to stop the terrorist team) is usually irrelevant to the player as the gameplay and interactions around it are the main point of attraction of these games. Another characteristic is as the duration of the game is not restricted by the length of the narrative or the story, and as the human to human interaction offers almost infinite different possibilities, is not rare to see players with several hundreds of hours invested in multiplayer games.

With all that said, the proposed definition of a 3D FPS for this document will be as follows: A First Person Shooter is a game where the player takes actions at a distance in a first person perspective, using primarily ranged weapons, but not excluding other kind of short-ranged weapons such as knives or fists. Presents at least a recognisable world and a set of physics and collision systems that determine the way the projectiles arrive to their targets and how the character interacts with the world. Finally, this genre of games can include singleplayer experiences and on-line or offline multiplayer interactions and according to this is the importance of the narrative to drive the actions of the player, where in offline games is of the utmost relevance whereas in online games is more secondary.

Based in this definition, we can extract that a FPS game, needs tight and responsive controls that allow players to aim with ease. Another important aspect is that the game must maintain a continuous feedback to the player's actions (i.e. if he is dealing or receiving damage). As the physic and collision systems condition the gameplay, they need to be consistent with the world presented and its impact on gameplay must be evident to the player. The Artificial Intelligence of enemies and allies must be interesting and advanced enough to

not slow down the progress of the player and finally depending on the focus of the game, the narrative, world and characters must be interesting and drive the player progress, and if there is a multiplayer mode, the game must provide the adequate tools to allow players communicate with each other.

3.3 Playability

As stated in the introduction, the Playability is derived from the term Usability that according to the ISO [19], is "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use". Usability can be applied to basically everything humans can interact to, so as the interaction between human and game has many particularities, a less broad concept was needed and thus Playability came to be. First of all we have to define the term gameplay, as is intrinsically tied to the Playability; according to the Fundamentals of Game Design [11], gameplay is the set of challenges and actions that a game offers. The gameplay is provided by the game mechanics, which are a set of rules or methods designed for interaction with the game state [28]. After those introductory terms and, as a first definition according to Usability first glossary [3], Playability is the degree to which a game is fun to play and usable, with an emphasis on the interaction style and plot-quality of the game; the quality of gameplay. Playability is affected by the quality of the storyline, responsiveness, pace, usability, customizability, control, intensity of interaction, intricacy, and strategy, as well as the degree of realism and the quality of graphics and sound.

The work of González, Vela, Simarro, and Padilla-Zea [31] give a more complete definition as they suggests that the concept of Playability is similar to the concept of User Experience (UX) for interactive systems in general. They defined Playability as the degree to which users can achieve goals effectively and efficiently, but with a special focus on the satisfaction and fun within a playful context of use. This definition is then expanded in the following Playability model (see figure 5), based in seven attributes:

1. **Satisfaction:** The gratification or pleasure derived from playing a complete video game or from some aspect of it. By definition is a highly subjective attribute, so is difficult to measure as depends on the preferences of each player. Is divided in Fun, Disappointment and Attractiveness.
2. **Learnability:** The capacity of the player to understand and master the system and mechanics of the game. Is divided in Skill, Difficulty, Frustration, Speed and Discovery.
3. **Effectiveness:** The time and resources necessary to offer players an entertaining experience whilst they achieve the various objectives of the game and reach the final goal. An 'Effective' video game is able to engage the player's attention from the beginning to the end of the game. Is subdivided in Completion and Structuring.
4. **Immersion:** The capacity of the video game contents to be believable, in such a way that the player becomes directly involved in the virtual game world. It has Conscious Awareness, Absorption, Realism, Dexterity and Socio-Cultural Proximity as attributes.

5. **Motivation:** The set of game characteristics that prompt a player to perform specific actions and continue undertaking them until they are completed. Is divided in Encouragement, Curiosity, Self-improvement and Diversity.
6. **Emotion:** 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. It has Reaction, Conduct and Sensory Appeal as attributes.
7. **Socialisation:** 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). Is divided in Social Perception, Group Awareness, Person Implication, Sharing, Communication and Interaction.

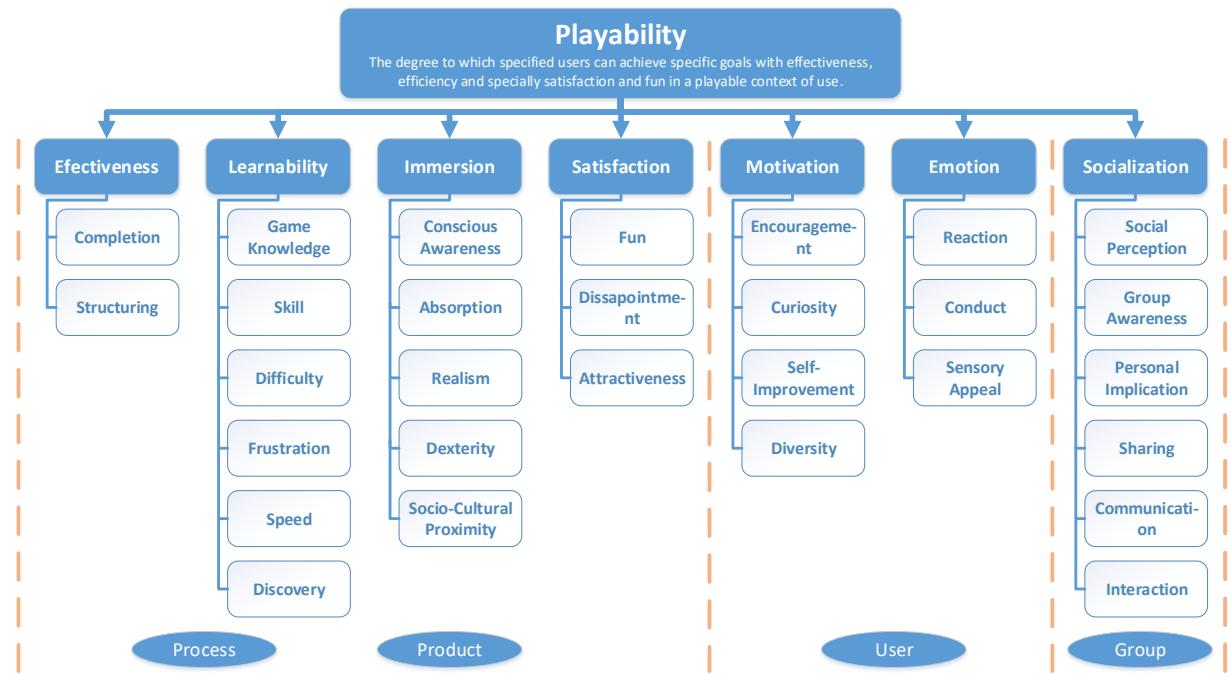


Figure 5: Playability model: attributes and properties which characterise the Player Experience, according to González et al.

Is important to note, that no all seven attributes of the playability model, will be covered, as some of the properties are considered not relevant to the context of this document, or are simply difficult or impractical to evaluate with a heuristic set. This is further developed in section 7.

3.4 User and Player Experience

As a starting point we have the definition provided by the International Organization for Standardization, ISO [19] that in the multi-part standard "Ergonomics of Human System Interaction" states that User Experience (UX) is the "person's perceptions and responses that result from the use or anticipated use of a

product, system or service". According to this definition the user experience includes all the users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviours and accomplishments that occur before, during and after use". This definition falls short in the case of video games, as the objective of the player goes beyond completing a task; playing a game is done primarily because of the joy it produces to the player, is intrinsically a highly subjective and personal experience, it describes the qualities of the player-game interactions and is typically investigated during and after the interaction with games. Bernhaupt [13] underlines that Player Experience (PX) is dependent on subjective experiences evoked by games and phases of play they offer, and that interaction paradigms of games may influence it.

As this term is tied to the human nature, is almost impossible to make a specific definition that all can agree on, and therefore there are abundant models in the literature that try to explain the structure of PX. In the work of Wiemeyer et al. [32] there is an extensive review of the different models of PX which are divided in two broad categories, Psychological and Integrative Models.

3.4.1 Psychological Models of Player Experience

As stated early, gaming is a personal experience and thus psychological models try to explain PX as well as the factors that contributes to it. For this reason and based in the research of Wiemeyer et al. [32] the following psychological models are summarised:

- **GameFlow:** Sweetser and Wyeth [30] applied the concept of *flow* (a particular state that emerges when people perform intrinsically motivated or *autotelic* activities, activities bearing their rewards in themselves) to gaming in order to explain enjoyment in games. Consists of eight elements: Challenge, skills, control, clear goals, feedback, immersion, and social interaction.
- **Fun of Gaming (FUGA) [26]:** Based on focus groups, expert interviews and questionnaire studies, propose a seven-factor model of PX which are the following: Sensory and imaginative immersion, tension, competence, flow, negative affect, positive affect, and challenge.
- **Core Elements of the Gaming Experience (CEGE):** Calvillo-Gámezetal et al. [15] proposed a model that was developed using qualitative methods. Identifies two essential factors influencing the experiences of immersion, flow and presence when playing digital games: Puppetry and video game perception. Puppetry denotes the interaction of the player with the game, and the video game perception denotes how the PX is dependent on the environment (graphics, sound and game-play). This model was chosen as basis to the new heuristic set because is considered that considers the most important aspects of the experience in a FPS game, and as the authors included a questionnaire to measure the observable variables in order to understand the behaviour of the latent constructs, so is easier to include these elements into the new heuristic set. For this reason, this model is more deeply explained in section 3.5.

3.4.2 Integrative Models of Player Experience

The Player Experience has a multidimensional nature, and for this reason a physiological approach may not be able to cover all aspects of PX, a multidisciplinary model that integrates psychological, sociological, physiological and bio-mechanical is needed. Is worth noting that most of this models are focused on the design on exergames (term used for video games that are also a form of exercise), so for example the ISCAL Model [33], the Dual Flow Model (DFM) [29] and the Four-Lens Model (4LM) [22] are out of the focus of this document. The Play Patterns and eXperience (PPAX) Framework developed by cowley et al. [16] connect three levels of game experience: game design patterns, the interplay of game context with player personality or tendencies, and state-of-the-art measures of experience. In an interdisciplinary collaboration that combines basic psycho-physiology research with game design patterns and machine learning, and generates new knowledge about the interplay between game experience and design.

3.5 Core Elements of the Gaming Experience

Of all the discussed PX models, is the one of Calvillo-Gámez et al. [15] that will be used as founding to the heuristic set, and for this reason it will be more deeply explained. This model is based in positive experience (enjoyment) while playing games which according to the authors is achieved by the player's perception of the video game and the interaction with it. This last two elements are the Core Elements of the Gaming Experience: Video game and Puppetry. These two elements are divided in latent variables, which are the subdivided onto observable variables. All latent variables depend on the observable ones. However, the observable variable is a consequence of the latent one. The authors proposed a questionnaire using the observable variables, which allow to understand the changes for the latent variables.

3.5.1 Video game

the video game is perceived by two elements, the **gameplay** and the **environment**, these are the latent variables of video games. Gameplay defines what the game is about, its *rules* and *scenario*. They refer to the “do’s and don’ts” that the player can do in the game. The story is the dressing of the rules, taking the abstraction of the rules into characters and scenarios. The Environment is the way the game is presented to player, the physical implementation into *graphics* and *sounds*, its describes then what the game looks and sound like.

3.5.2 Puppetry

Represents the interaction between player and video game, describes how the player starts approaching the video-game until eventually the game being played is the outcome of the actions of the player. This process of interaction is affected by three conditions: **control**, **ownership** and **facilitators**. First we have control, which is the subdivided in:

- **Controllers:** Are the basic tool that the players need to take control of the game, is how he manipulates the different character or objects on screen. Its only refers to the player's manipulation of the physical

device.

- **Small Actions:** Are the basic blocks that allow the player to get the character to do something on the screen. Pressing button “x” is part of the controller, the fact that the character jumps is a small action.
- **Memory:** Is the element of control that gives the player the repertoire of actions to get into the game and that can be recalled at a given moment. The player has to memorise the bindings between controllers and small actions.
- **Point-of-view:** Is how the information is displayed to the player. The player is able to see what is going on in the game from different angles, depending on the game.
- **Goal:** is the top level objective of the game, the player must be clear in what is the overall objective of the game in order to get control of the game.
- **Something to do:** That is, to keep the player busy doing something.

The second condition is Ownership, which has the following observable variables:

- **Big actions:** Those actions that the player implements as strategies, by using a collection of small actions, in order to complete the goal of the game.
- **Personal goals:** The player can also draw his personal goals, and use big actions to complete them.
- **Rewards:** The game acknowledges the ownership of the player by providing rewards.
- **you but-not-you:** Refers to the idea that the player is engaging in activities that are alien to his everyday actions, which allows the player to create his personal goals.

The last element of the theory are the facilitators, which are the most subjective elements of the CEGE:

- **Time:** The amount of time that the player is willing to play.
- **Aesthetic values:** The aesthetic values of the game are important in facilitating ownership. If the game looks attractive, is amusing to observe or the music is of the pleasure of the player, then he may be willing to try longer.
- **Previous experiences:** The previous experiences with similar games or other games.

Finally, and in order to show graphically the relationships among observable and latent variables the figure 6 is presented.

These observable variables are assessed using the Core Elements of the Gaming Experience Questionnaire (CEGEQ), included in table 40, it uses a 7-point Likert scale and is to be administered after the participant has finished playing with the game.

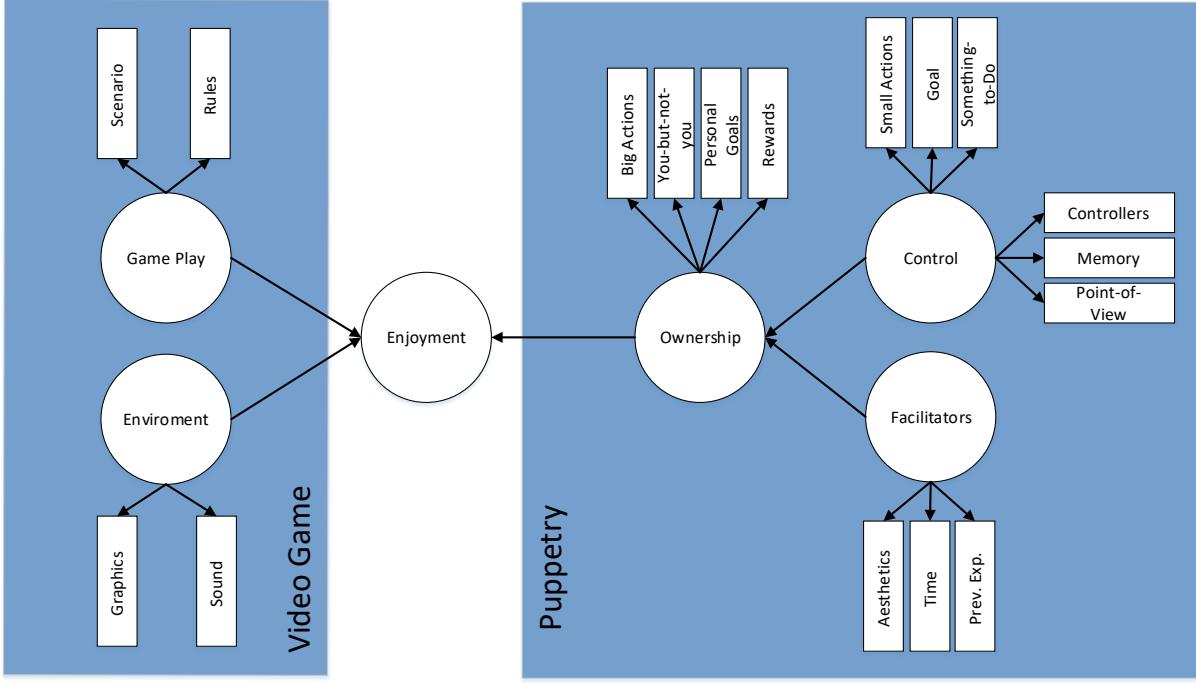


Figure 6: The CEGE model of Calvillo-Gámezetal et al: The figure depicts the relationships among observable (rectangles) and latent (circles) variables.

3.6 Heuristic evaluation

The heuristic evaluation is an usability inspection for computer software where a group of evaluators examine the interface in search of discrepancies with a set of usability principles, the heuristics. This method is used to detect Usability problems that can hinder the User Experience (UX). In this section a review of some heuristic set available in the literature are shown. As starting point we have the one that was proposed by Nielsen [23], being the most broadly known set of heuristic for interactive applications. Is composed by 10 general principles for interaction design. It can be appreciated that many of the game-specific set shown in this document share many points with Nielsen's, but there are many aspects of games that are not covered by it.

Table 3: Nielsen's Heuristics

Nº.	Nielsen's Heuristics
1	Visibility of system status
2	Match between system and the real world
3	User control and freedom
4	Consistency and standards
5	Error prevention
6	Recognition rather than recall
7	Flexibility and efficiency of use
8	Aesthetic and minimalistic design
9	Help users recognize, diagnose and recover from errors
10	Help and documentation

Concerning specifically the Playability and PX, Pinelle et al. [24], developed a set of Game heuristics based on the analysis of PC game reviews from the popular gaming website, GameSpot. The review covered 108 different games and included 18 from each of 6 major game genres. Based in this information, they identified twelve common classes of usability problems seen in games. Finally, using this information, developed ten Playability heuristics shown in table 4.

Table 4: Game Heuristics according to Pinelle et al.

Nº.	Game Heuristics
1	Provide consistent responses to the user's actions.
2	Allow users to customize video and audio settings, difficulty and game speed.
3	Provide predictable and reasonable behaviour for computer controlled units.
4	Provide unobstructed views that are appropriate for the user's current actions
5	Allow users to skip non-playable and frequently repeated content.
6	Provide intuitive and customizable input mappings.
7	Provide controls that are easy to manage, and that have an appropriate level of sensitivity and responsiveness.
8	Provide users with information on game status.
9	Provide instructions, training, and help.
10	Provide visual representations that are easy to interpret and that minimize the need for micromanagement.

Another set, called the Heuristic Evaluation for Playability (HEP), developed by Desurive et al. [17] using the current literature as a base, and was reviewed by several Playability experts and game designers. These heuristics are divided in four categories: Gameplay, Game Story, Mechanics and Usability and is depicted in table 35.

Based on the HEP heuristics, in 2009 Desurive et al. [18] created an improved set of Game Usability Heuristics called PLAY for evaluating and designing better games. According to the authors, HEP was found to be useful only in limited circumstances and for this reason PLAY was developed to be a generalised foundation that could then be modified for each specific game. To create PLAY they used three sets of questionnaires, one to correspond to each of the three different game genre, Action Adventure, FPS and RTS (Real-time Strategy, a genre of game where the participants position and maneuver units and structures under their control to secure areas of the map and/or destroy their opponents' assets). The questionnaires also contained a list of games divided into two categories: High Rank and Low Rank. Game rankings were taken from Metacritic, a website that aggregates rankings from several online game reviewers. High Rank games were games with scores of 80 or higher. Low Rank games were games with scores of 50 or lower. Based on the difference found by the surveyed gamers between High and Low-ranked games the new set was crafted, which is divided in three categories: Gameplay, Coolness/Entertainment/Humor/Emotional Immersion and Usability & Game Mechanics. Each category is subdivided in their respective heuristics with its respective explanation. This set is presented in the appendix in tables 37 to 39.

Korhonen and Koivisto [21] published a specific set of heuristics for mobile games. This set is divided in

three groups, Game Usability, Mobility and Gameplay and is shown in table 5:

Table 5: Heuristics of Korhonen and Koivisto for evaluating mobile games

Nº.	Game Usability Heuristics
GU1	Audio-visual representation supports the game
GU2	Screen layout is efficient and visually pleasing
GU3	Device UI and game UI are used for their own purposes
GU4	Indicators are visible
GU5	The player understands the terminology
GU6	Navigation is consistent, logical, and minimalist
GU7	Control keys are consistent and follow standard conventions
GU8	Game controls are convenient and flexible
GU9	The game gives feedback on the player's actions
GU10	The player cannot make irreversible errors
GU11	The player does not have to memorize things unnecessarily
GU12	The game contains help
Nº.	Mobility Heuristics
MO1	The game and play sessions can be started quickly
MO2	The game accommodates with the surroundings
MO3	Interruptions are handled reasonably
Nº.	Gameplay Heuristics
GP1	The game provides clear goals or supports playercreated goals
GP2	The player sees the progress in the game and can compare the results
GP3	The players are rewarded and rewards are meaningful
GP4	The player is in control
GP5	Challenge, strategy, and pace are in balance
GP6	The first-time experience is encouraging
GP7	The game story supports the gameplay and is meaningful
GP8	There are no repetitive or boring tasks
GP9	The players can express themselves
GP10	The game supports different playing styles
GP11	The game does not stagnate
GP12	The game is consistent
GP13	The game uses orthogonal unit differentiation
GP14	The player does not lose any hard-won possessions

Even if the focus of these heuristics are mobile games, due to its modular nature, are easy to apply in the evaluation of games in other platforms as well.

The final set of heuristics presented in this document was proposed in the work of González, Vela, Simarro, and Padilla-Zea [31] and is called the Playability and Hedonic Evaluation Tool (PHET), which takes the different Facets of Playability and suggest the heuristics to evaluate them. The complete set is presented in the appendix, in table 36.

As stated earlier many of these heuristics sets have similarities with Nielsen's, but is obvious that the usability of a video game, even if crucial, is only one aspect of the Playability. Another remarkable aspect is that the reviewed heuristics sets embraced the Multi-faceted nature of games and grouped the heuristics accordingly.

3.7 Genres in Usability Evaluations

Pinelle et al. [17] used 108 game reviews from Gamespot to identify the biggest and most common problems on these games, and excluding technical problems and issues related to fun and engagement, they created 12 categories, depicted in table 6.

Table 6: List of usability problems found in video games according to Pinelle et al.

Problem Category	key Issues
Consistency	Poor hit detection, poor in-game physics, inconsistent response to input
Customizability	Does not allow user to change video and audio settings, difficulty, or game speed
Artificial intelligence	Problems with pathfinding, problems with computer controlled teammates
View mismatch	Bad camera angle, view is obstructed, view does not adjust to user's action quickly enough
Skip content	Cannot skip video and audio clips, frequently repeated sequence
Input mappings	Bad input mappings, limited device support, limited controlcustomization
Controls	Oversensitive controls, unnatural controls, unresponsive controls
Game status	Does not provide adequate information on character, game world, or enemies. visual indicators, icons, and maps are inadequate.
Training and help	Does not provide default and recommended choices; does not provide suggestions and help; does not provide adequate documentation, instructions, tutorials, and training missions
Command sequences	Learning curve is too steep; requires too much micromanagement; command sequences are complex, lengthy, and awkward, making the game difficult to play
Visual representations	Bad visualization of information, too much screen clutter, too many characters or game elements on the screen at the same time, difficult to visually distinguish interactive content from non-interactive content
Response times	Slow response time interferes with user's ability to interact with the game successfully

These problems were then used to develop the heuristic set summarised in table 4, but they also found that there is a correlation between the frequency of some problems and the genre of the game, as some of the aspects of gameplay are emphasised in that particular genre. This analysis covered the Role Playing, Sports, Action, Strategy, Adventure and Shooter genres. In the case of the latter, the low incidence problems (with an incidence of 2 or lower) were: skip content (0), visual representations (1), view mismatch (1), customizability (1), training and help (2), command sequences (2), input mappings (2). The high incidence problems (with a frequency of 5 or more) were, consistency (8), controls (5), artificial intelligence (5).

In their analysis, they concluded that as different FPS usually have some degree of similarity, they tend to use identical key and mouse mappings; the visual design is also alike, for example the case of health, Armour and ammunition indicators. For this reason, these factors are not usually the problem, contrary to the sensitivity and responsiveness of controls. Another common problem is the lack of consistency in the response of the game to actions of the user, for example games that responds inconsistently to the inputs of the user, or inconsistencies in the application of physics models and hit detection. There are also frequent issues with the Artificial Intelligence of enemies and other non-player characters.

Based in the results of this work can be concluded that the genre is indeed a main concern in the evaluation

of the Playability of a game; as the gameplay is heavily influenced by the genre, there are some problems more critical to the experience than others. In the case of shooters is primordial the consistency between the inputs of the player and reactions of the character, enemies and environment; the controls must feel natural, responsive and precise. Finally, the artificial intelligence of the teammates controlled by the computer and enemies need to be advanced enough to not hinder the progress of the player, and to respond in interesting ways to the actions of the player.

4 Attributes and Properties Selection

To develop the new set of heuristics, four main sources of information are used. In the first place we have the main characteristics of the application itself, the First Person Shooter games and the usual problems that affect them, detected by Pinelle et al. [17] In second place we have the Playability model of González et al. (see figure 5), which defines seven attributes with its corresponding properties. In third place we have the Player Experience model proposed by Calvullo-Gámezetal et al. (see figure 6) where they propose several observable variables that affect the PX. Finally some aspects of the usability, and therefore from the Nielsen heuristics [23] were adapted to the context of this investigation.

4.1 Omitted Attributes and Properties

In a first step, the number of possible heuristics was narrowed, as the methodology of Daniela Quiñones and Cristian Rusu [27] suggest a number between 10 and 16, so in this section are explained what aspects were omitted and why. From the Playability model some aspects will not be considered as the author consider to be too difficult or impractical to evaluate them with a heuristic set or simply they are not important given the context of this document. To deepen in the reasons behind this decisions, table 7 is presented.

Table 7: Omitted Attributes and Properties

Attributes	Properties Omitted	Reasons
Effectiveness		All properties are included.
Learnability		All properties are included.
Immersion	Absorption	Is defined as the focus of all the player's abilities and attention on overcoming the game's challenges, which is considered impractical to evaluate with the presented method.
	Dexterity	Refers to the player's dexterity in carrying out different movements and actions in the virtual world in which they are immersed, this property was not considered important in the context of FPS games.
	Socio-Cultural Proximity	This property states that games should have certain socio-cultural characteristics that the player can identify with. In the opinion of the author, games should be more appealing to certain persons (the target audience) but this is beyond the facilities of an evaluator.
Satisfaction	Fun Disappointment Attractiveness	The properties of this attribute say that the game must be entertaining and attractive and that players do not feel disappointed or uneasy while playing. These attribute was completely omitted as it was considered to be extremely subjective and hard to evaluate with the proposed method.
Motivation	Self-Improvement	This property was omitted, as the improvement of the abilities of the player is difficult to asset, and the improvement of the character is not always a characteristic of the gameplay of FPS games.
Emotion	Reaction	This properties is about the reactions that the game make on the emotions of the player, this is considered to be too personal and subjective and not paramount to the Player Experience on FPS games.
Socialization	Social Perception	Is the degree of social activity used and understood by players, which is not considered to be important in the context.
	Sharing	This refers to the shared game resources, and how they are managed, this was considered to be unimportant in the FPS games context and partially covered by the rest of the properties.

In the case of the Player Experience model, the observable variables are asserted using a questionnaire,

and based on that, some preliminary heuristics were extracted. But many of them were already covered by other heuristics extracted from the rest of the sources contemplated, as is explained in table 8.

Table 8: Omitted aspects from the Player Experience Model

Heuristic Prototype	Reason
The game must be enjoyable, encouraging the player to play the game again and reducing frustration.	It was considered that the enjoyment and frustration can't be evaluated efficiently with the proposed method, and thus were omitted.
The player must feel in control of the game, he must know the possible actions and the rules in order to advance, and the controls must respond as the player expect.	These aspects are considered important, but they are already included by other heuristics. (by Game Fairness and Difficulty)
The point of view of the game mustn't spoil the game experience and all the information needed is shown on screen.	As this document focuses on FPS games, the point of view is not an issue, and the rest is already covered. (by Aesthetic and Minimalistic Design)
The game looks good and graphics are not plain.	These aspects are considered important, but they are already included by other heuristics. (by Game Fairness and Difficulty)
The game kept constantly motivating the player to keep playing and knows how to manipulate the game to move forward.	These aspects are considered important, but they are already included by other heuristics. (by World Aesthetics, Rules and Mechanics Consistency)
The graphics and sound effects were appropriated and related to the scenario, the actions of the player and to each other.	These aspects are considered important, but they are already included by other heuristics. (by World Aesthetics, Rules and Mechanics Consistency)

4.2 Attributes, properties and characteristics considered

In this section, all the aspects that will be effectively considered in the new heuristic set are shown and explained.

4.2.1 FPS characteristics and common problems

Based on the definition given in this document of FPS games, and in the most common problems found by Pinelle et al. [17], the following preliminary prototypes of heuristics were extracted.

- The controls tend to follow the industry standards, are responsive and intuitive and the game respond consistently to the player's input.
- The collision and physic systems are fair and consistent on its execution through the game.
- The artificial intelligence on enemies must be engaging and interesting but accord to the selected difficulty, and on allies (if apply) must be advanced enough to not slow down the progress of the player.
- The narrative, world and characters must be interesting and drive the player progress.
- If there is a multiplayer mode, the game must provide the adequate tools to allow players communicate with each other.

4.2.2 Playability model

Based on six of the seven attributes of the playability model of González et al. [31], the following prototypes of heuristics were formulated. One attribute and several properties of the model were omitted (see table 7)

- **Effectiveness:** The game structures and paces its objectives and challenges in order to keep the player's attention but not to overwhelm or frustrate him, also presents secondary objectives and content for players looking for additional challenges. This correspond to the properties of Completion and Structuring.
- **Learnability:** The game exploits the previous knowledge of the player about similar games, offering tutorials if needed, helping the less skilled players, but not boring the expert ones. The game paces the introduction of new concepts and content, not too slowly to bore, but not too fast to overwhelm. The game also presents different levels of difficulty and uses different approaches to teach new concepts and mechanics in order to lessen the frustration of the player. This corresponds to the properties of Game Knowledge, Skill, Difficulty, frustration, Speed and Discovery.
- **Immersion:** The world presented must be believable in an aesthetic sense and consistent with the rules, mechanics and scenarios presented. The player must aware of the consequences of his actions in the world presented. This correspond to the properties of Conscious Awareness and Realism.
- **Motivation:** The game promotes the curiosity of the gamer, allow him to improve his abilities and presents diverse challenges that reward the player consistently to the effort made to overcome them. This correspond to the properties of Encouragement, Curiosity and Diversity.
- **Emotion:** The game uses different sensory channels to stimulate the player's senses in order to lead the player through different emotions thanks to the stimuli they provide. This correspond to the properties of Conduct and Sensory Appeal.
- **Socialization:** In the case of multiplayer games, the player must be conscious of being part of a team and hence, rules, challenges and objectives need to be developed in order to raise the player's awareness of their role in the success of the group, and for this reason these games should offer communication mechanisms that enable optimal interchange of information among players. In single player, the relationship between the player's avatar and other characters must be meaningful. This correspond to the properties of Group Awareness, Personal Implication, Communication and Interaction.

4.2.3 Player Experience Model

Based in the questionnaire proportioned by the authors and included in the table 40, the following preliminary prototype of heuristics where extracted:

- The player must be doing "something" at all times.
- The game is fair and the player understand the rules of the games, which present an adequate difficult and challenges.

4.2.4 Usability

There are some aspects of usability that must be asserted, and for that reason were adapted to the context of video games.

- The game gives immediate and consistent feedback to the player's actions through music, sound and visual effects or controller vibration.
- The User Interface of the game shows all the information the player needs in a clean, clear and visually pleasant way.
- The player cannot make irreversible errors.

Finally and in order to determine if some of the currently available sets fulfil all the aspects detailed in the previous section, the table 9 is presented, where it can be appreciated if the heuristic cover completely, partially or simply does not cover each of the aspects.

Table 9: Comparative table

	Characteristics and attributes	Game Heuristics (Pinell)	Heuristic Evaluation for Playability (HEP)	Play Heuristics	Mobile Games
Usability	The game gives immediate and consistent feedback to the player's actions through music, sound and visual effects or controller vibration.	Not Covered	Covered	Covered	Partially Covered
	The UI of the game shows all the information the player needs in a clean, clear and visually pleasant way.	Partially Covered	Covered	Covered	Covered
	The player cannot make irreversible errors.	Covered	Partially Covered	Covered	Covered
FPS Attributes and Common Problems	The controls tends to follow the industry standards, are responsive, intuitive and the game respond consistently to the player's input.	Covered	Partially Covered	Partially Covered	Partially Covered
	The collision and physic systems are fair and consistent on its execution through the game.	Not Covered	Not Covered	Not Covered	Not Covered
	The artificial intelligence on enemies must be engaging and interesting, in allies must not hinder the progress of the player.	Partially Covered	Partially Covered	Partially Covered	Partially Covered
Playability Model	The narrative, world and characters must be interesting and drive the player progress.	Not Covered	Partially Covered	Covered	Partially Covered
	If there is a multiplayer mode, the game must provide the adequate tools to allow players communicate with each other.	Not Covered	Not Covered	Not Covered	Not Covered
	Effectiveness.	Not Covered	Covered	Partially Covered	Partially Covered
Player Experience Mode	Learnability.	Partially Covered	Partially Covered	Covered	Partially Covered
	Immersion.	Not Covered	Covered	Partially Covered	Partially Covered
	Motivation.	Not Covered	Partially Covered	Covered	Partially Covered
	Emotion.	Not Covered	Not Covered	Covered	Not Covered
	Socialization.	Not Covered	Not Covered	Not Covered	Not Covered
	The player must be doing "something" at all times.	Not Covered	Not Covered	Not Covered	Not Covered
	The game is fair and the player understand the rules of the games, which present an adequate difficult and challenges.	Not Covered	Covered	Partially Covered	Not Covered

It can be appreciated that none of the presented heuristic sets satisfies every aspect considered important or relevant to evaluate the Playability and PX on FPS games. Based on this comparison, some heuristics will be used as foundation to the development of the new set. If the aspect was not covered by any of the presented sets a completely new one will be developed. After all this process, the first list of heuristics that includes all the attributes and properties is shown in table 10, where the source can be easily appreciated. The function of this table is to show clearly the source of the new heuristic set, but is worth noting that there are some redundant aspects, like difficulty, so there will be further modifications to the definitions presented in this first table.

Is important to note, that in this stage, with this preliminary set of heuristics, the template (see table 1) proposed by the methodology Daniela Quiñones and Cristian Rusu [27] was filled in order to formalise them, leading to the first version of new set of heuristics, that was validated and refined through experiments, detailed in the next section. Finally and for the sake of brevity the complete template is shown in this document only for the final version of the new set (see section 7).

Table 10: Preliminary set of heuristics

	ID	Name	Definition	Source
Usability	1	Feedback and Game Status	The game gives immediate and consistent feedback to the player's actions and game events through music, sound and visual effects or controller vibration.	Play Heuristics HEP
	2	Aesthetic and Minimalist Design	The UI of the game shows all the information the player needs in a clean, clear non-intrusive and visually pleasant way.	Play Heuristics HEP
	3	Error Prevention	The player cannot make irreversible errors.	Mobile Games Game Heuristics
FPS attributes and common problems	4	Controls Standards and Responsiveness	The controls tends to follow the industry standards, are responsive, intuitive and the game respond consistently to the player's input.	Game Heuristics
	5	Collision and Physics Consistency	The collision and physic systems are fair and consistent on its execution through the game.	New
	6	Artificial Intelligence Engagement	The artificial intelligence on enemies must be engaging and interesting, in allies must not hinder the progress of the player.	Play Heuristics HEP
	7	Multiplayer Communication	If there is a multiplayer mode, the game must provide multiple and adequate tools to allow players communicate with each other.	New
Playability model	8	Objectives Structuring and Pacing	The game structures and paces its objectives and challenges in order to keep the player's attention but not to overwhelm or frustrate him, also presents secondary objectives and content for players looking for additional challenges	Effectiveness (Completion and Structuring)
	9	Difficulty, Help and Previous Knowledge	The game exploits the previous knowledge of the player about similar games, offering tutorials if needed, helping the less skilled players, but not boring the expert ones. . The game also presents different levels of difficulty and uses different approaches to teach new concepts and mechanics in order to lessen the frustration of the player	Learnability (Game Knowledge, Skill, Difficulty, frustration, Speed and Discovery)
	10	World Aesthetics, Rules and Mechanics Consistency	The world presented must be believable in an aesthetic sense and consistent with the rules, mechanics and scenarios presented. The player must aware of the consequences of his actions in the world presented	Immersion (Conscious Awareness and Realism)
	11	Curiosity, Challenges and Rewards	The game promotes the curiosity of the gamer, allow him to improve his abilities and presents diverse challenges that reward the player consistently to the effort made to overcome them	Motivation (Encouragement, Curiosity and Diversity)
	12	Emotional Stimuli	The game uses different sensory channels to stimulate the player's senses in order to lead the player through different emotions thanks to the stimuli they provide.	Emotion (Conduct and Sensory Appeal)
Player Experience Model	13	Socialization	In the case of multiplayer games, the player must be conscious of being part of a team and hence, rules, challenges and objectives need to be developed in order to raise the player's awareness of their role in the success of the group. In single player, the relationship between the player's avatar and other characters must be meaningful.	Socialization (Group Awareness, Personal Implication, Communication and Interaction)
	14	Game Fairness and Difficulty	The game is fair and the player understand the rules of the games, which present different difficulty levels.	HEP

5 Validation of the New Set of Heuristics

In order to validate the effectiveness and efficiency of the new set of heuristics in the evaluation of the playability of First Person Shooter Games, and according to the methodology of Daniela Quiñones and Cristian Rusu [27], two experiments were performed, first an heuristic evaluation, and then an expert judgement.

5.1 Heuristic Evaluation

In this experiment, the new set of heuristic is compared to an existing, more generic set on one selected case study. In the heuristic evaluation, different experts, play the game and try to identify Playability/Player Experience problems using the heuristic set as a guide. Then using the number of problems found by each group and other indicators, the effectiveness of the new set can be evaluated and eventual problems detected.

5.1.1 Selection of the Existing set of Heuristics

The first step was the selection of an existing set of heuristics to compare it against the new one. Of all studied sets, Nielsen's [23] was discarded as is too generic for the purposes of this evaluation. The heuristics of Korhonen and Koivisto [21] were also discarded as they focus on mobile games. Another aspect considered, was the number of heuristics of the set, as increases the difficulty of use for the evaluators, as no one has experience in the evaluation of the Playability/Player Experience of games. Finally, the Game Heuristics of Pinelle et al [24] were selected, for its reduced number of heuristics and for its generic nature as it was made for the evaluation of all genres of games.

Table 11: Comparison of the first iteration of the new set and the Game Heuristics [24] of Pinelle et al.

ID	First Person Shooter Heuristics	Nº.	Game Heuristics
1	Feedback and Game Status	1	Provide consistent responses to the user's actions.
2	Aesthetic and Minimalist Design	2	Allow users to customize video and audio settings, difficulty and game speed.
3	Error Prevention	3	Provide predictable and reasonable behaviour for computer controlled units.
4	Controls and Responsiveness	4	Provide unobstructed views that are appropriate for the user's current actions
5	Collision and Physics Consistency	5	Allow users to skip non-playable and frequently repeated content.
6	Artificial Intelligence Engagement	6	Provide intuitive and customizable input mappings.
7	Multiplayer Communication	7	Provide controls that are easy to manage, and that have an appropriate level of sensitivity and responsiveness.
8	Structure of Objectives and Pacing of the Game	8	Provide users with information on game status.
9	Help and Tutorials	9	Provide instructions, training, and help.
10	World Aesthetics, Rules and Mechanics Consistency	10	Provide visual representations that are easy to interpret and that minimize the need for micromanagement.
11	Curiosity, Challenges and Rewards		
12	Emotional Stimuli		
13	Socialization and Character Relationships		
14	Difficulty and Game Fairness		

5.1.2 Selection of Experts and Test Groups

Due time and resources constraints, only six people were used in one case study. Of these six people, three have experience in heuristic evaluation and games in general, one has vast knowledge in this kind of evaluation

and usability but not in games and the last two were selected for their knowledge in First Person Shooter and games in general. In the case of the last two, special aid was given to them during the evaluation as they had little experience in the field of heuristic evaluation, but their feedback was considered important as experts on this kind of game.

Using the limited resources available, the idea was to make the two groups as similar as possible, for that reason the group using the Game Heuristics, the *Control group*, consisted in two experts in heuristic evaluation and games, and one expert on FPS. The second group, using the first iteration of the new set, called the *Experimental group* consisted in the remaining experts.

5.1.3 Selection of the Case Study

In order to select the game that would be evaluated, these criteria were considered:

1. The game should be free, allowing the evaluators to play in their own computers.
2. Its hardware requirements should not be high, as no every evaluator has a gaming computer.
3. The game should not be a masterpiece, in order to make easier to find Playability/Game Experience problems.

With this in account, the game selected is *Modern Combat 5: eSports FPS* a game developed by Gameloft [2] and released in 2014 in many different platforms. It was chosen because it went free to play and can be played easily in almost any computer, also due its mobile roots, is not considered a great game making it a perfect case study.

5.1.4 Evaluation of the effectiveness of the new set

To evaluate the effectiveness of each set of heuristics, some indicators are extracted and then used to compare the results obtained by both groups.

1. Number of playability problems identified.
2. Number of specific playability problems identified.
3. Number of usability problems identified qualifies as more severe.
4. Number of usability problems identified qualifies as more critical.

Regarding the first point, three groups of problems detected by the heuristic evaluation are expected, problems identified by both groups, problems identified only by the experimental group (with the new set) and problems identified only by the control group (with the existing set). If the exiting set identifies more problems, the new set may have issues that must be reviewed. The second point makes reference to the ability of each heuristic set to detect problems specific to the application (in this case the FPS games). The last review the capabilities in terms of the number of more severe and more critical problems found. These point will be further explained in the analysis of results.

5.2 Expert Judgement

In the expert judgement the feedback of the experts about the characteristics of the new set is collected, considering the following four dimensions:

1. **Utility:** How useful the usability (playability) heuristic is.
2. **Clarity:** How clear the usability (playability) heuristic is.
3. **Ease of use:** How easy was to associate identified problems to the usability (playability) heuristic.
4. **Necessity of additional examples:** How necessary would be to complement the usability heuristic with examples.

Each heuristic is evaluated separately on each dimension, using a five points Likert scale. The experts assigns a value between one and five for each dimension, were one indicates that the heuristic does not comply with the dimension and five indicates that complies completely (see table 12 as an example). Then the averages are calculated and based on the results, some conclusions can be extracted, where for example, a low average might indicate that the heuristic require revision.

Table 12: Table included in the Expert Judgement to assert the Utility of the heuristics, according to Daniela Quiñones and Cristian Rusu [27]

Utility of Heuristics						
ID	Name	Completely useless	Useless	Neutral	Useful	Completely useful
1	Feedback and Game Status					
2	Aesthetic and Minimalist Design					
3	Error Prevention					
4	Controls and Responsiveness					
5	Collision and Physics Consistency					
6	Artificial Intelligence Engagement					
7	Multiplayer Communication					
8	Structure of Objectives and Pacing of the Game					
9	Help and Tutorials					
10	World Aesthetics, Rules and Mechanics Consistency					
11	Curiosity, Challenges and Rewards					
12	Emotional Stimuli					
13	Socialization and Character Relationships					
14	Difficulty and Game Fairness					

Is important to note that all six experts (both groups) were surveyed, because the experimental group used more deeply the new heuristics and saw in practice its strengths and weaknesses making they opinion relevant. In the case of the control group, they were surveyed after they worked with the existing heuristic set, and even if they did not have the opportunity to use the new set, they know the characteristics of the existing one, making them easy to compare and determine if something was omitted in the new set.

5.3 Results of the Heuristic Evaluation

In this section all the results and information extracted from the heuristic evaluation will be discussed. Once the heuristic evaluation was finished, the first step taken was the deletion of every duplicated problem on each group for its later analysis. The complete list of problems can be found in the appendix on tables 41, 42 and 43.

5.3.1 Control Group

First we have the raw numbers obtained by the control group using the game heuristics of Pinelle et al. summarised in table 13, where it can be seen that this group found 15 different problems in total and the experts manage to associate correctly the heuristic with the problem 80% of the time.

Table 13: Total of problems found with the control heuristics, with the number of correct and wrong associations

ID	Heuristic Description	Problems found	Correct Associations	Wrong Associations
1	Provide consistent responses to the user's actions.	4	3	1
2	Allow users to customize video and audio settings, difficulty and game speed.	2	2	0
3	Provide predictable and reasonable behaviour for computer controlled units.	1	1	0
4	Provide unobstructed views that are appropriate for the user's current actions	2	2	0
5	Allow users to skip non-playable and frequently repeated content.	1	0	1
6	Provide intuitive and customizable input mappings.	1	1	0
7	Provide controls that are easy to manage, and that have an appropriate level of sensitivity and responsiveness.	1	0	1
8	Provide users with information on game status.	2	2	0
9	Provide instructions, training, and help.	0	0	0
10	Provide visual representations that are easy to interpret and that minimize the need for micromanagement.	1	1	0
Total		15	12	3
Percentage		100%	80%	20%

5.3.2 Experimental Group

In the case of the experimental group, using the first version of the new heuristics for FPS games, the experts found 25 different problems in total and associated them correctly to the heuristic the 76% of the time. This data is summarised in table 14.

Table 14: Total of problems found with the new heuristics, with the number of correct and wrong associations

ID	Name	Problems found	Correct Associations	Wrong Associations
1	Feedback and Game Status	4	3	1
2	Aesthetic and Minimalist Design	3	3	0
3	Error Prevention	3	2	1
4	Controls and Responsiveness	3	2	1
5	Collision and Physics Consistency	2	2	0
6	Artificial Intelligence Engagement	1	1	0
7	Multiplayer Communication	1	1	0
8	Structure of Objectives and Pacing of the Game	3	3	0
9	Help and Tutorials	1	1	0
10	World Aesthetics, Rules and Mechanics Consistency	1	0	1
11	Curiosity, Challenges and Rewards	0	0	0
12	Emotional Stimuli	1	0	1
13	Socialization and Character Relationships	1	1	0
14	Difficulty and Game Fairness	1	0	1
Total		25	19	6
Percentage		100%	76%	24%

5.3.3 Analysis of the Heuristic Evaluation data

In this evaluation, in a satisfying result, the group with the new set of heuristics found the 62.5% of the total number of problems, this does not mean that the new set is better than the existing one, and further analysis must be conducted, but these numbers may indicate that it was easier to find problems using the specific set of heuristics.

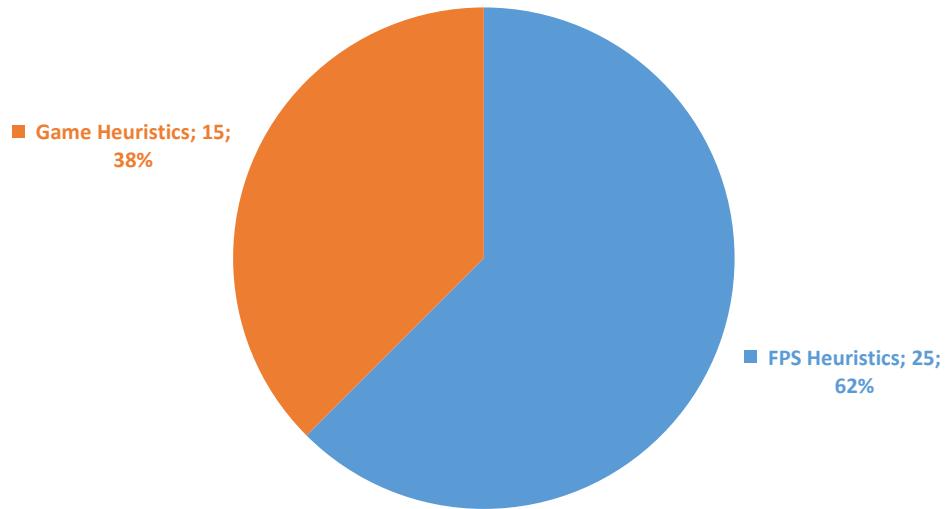


Figure 7: Number of problems found by each heuristic set

Regarding to the correct and wrong associations of each group, it can be appreciated that, in general, both heuristics set performed fairly well, with an 80% of correct associations for the Game heuristics, and 76% for the FPS ones. Most wrong associations were probably due the inexperience of the evaluators and

perhaps some rush on their part, as in the majority of the wrong associations the mistake seemed pretty hard to make.

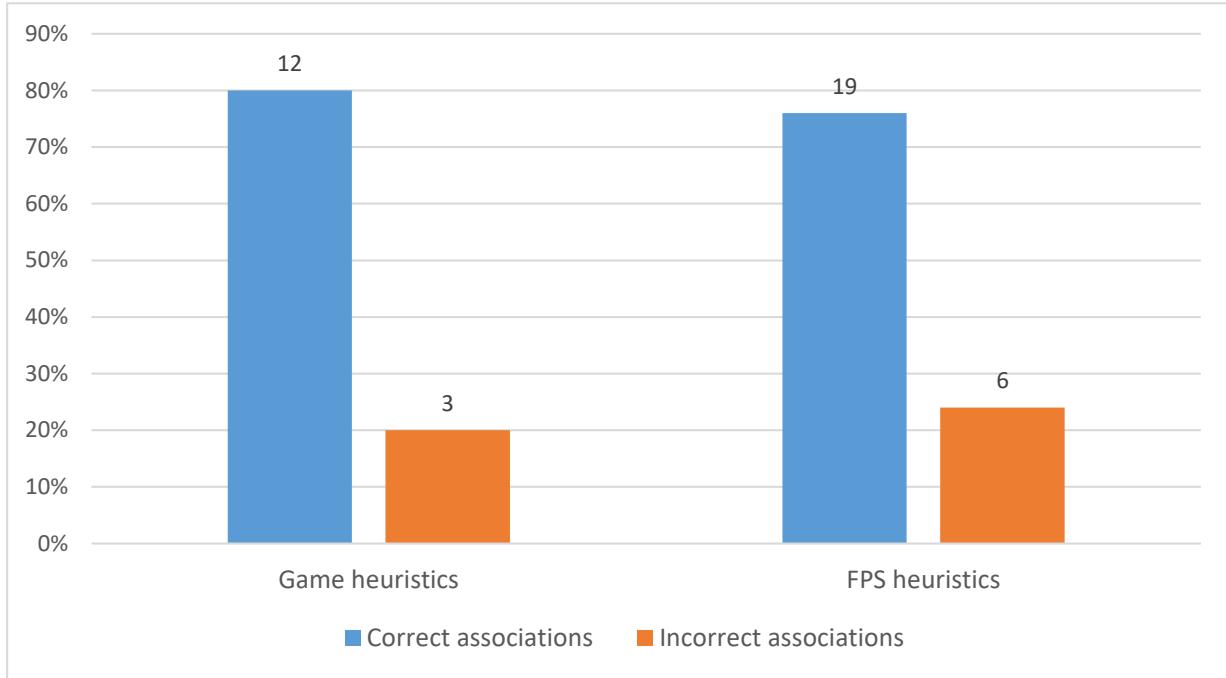


Figure 8: Correct and wrong associations between problem and heuristics of each set

5.3.4 Effectiveness of heuristics in terms of number of usability problems identified

To compare both sets in terms of number of usability problems identified, all problems were classified into the following three categories:

1. (P1) Problems identified by both groups of evaluators.
2. (P2) Problems identified only by the group that used the new set of heuristics.
3. (P3) Problems identified only by the group that used comparison heuristics.

Table 15: Summary of the problems found in each category

Problem Category	Total	Percentage
P1: Problems identified by both groups of evaluators.	6	18%
P2: Problems identified only by the group that used the new set of heuristics.	19	56%
P3: Problems identified only by the group that used comparison heuristics.	9	26%
Total of problems	34	100%

The group of the new set, found 25 different problems in total and the control group found 15. As can be seen in table 15, six problems were identified by both sets (P1), 19 only by the new set (P2) and nine only

by the control set (P3). First, and in terms of raw numbers, the results were very good for the new set, but even so, there were nine potential problems detected only by the control group. But of these nine problems of P3, seven could be easily mapped to a heuristic of the new set. Finally, and regarding to the two problems that cannot be easily mapped to the new set, they are both related to the heuristic that states: "Allow users to customise video and audio settings, difficulty and game speed", specifically to the customisation of video settings (which was indeed very limited in the game). In the opinion of the author, this kind of problems should not be evaluated by this method, because it would assume that the player is using a computer, because they can vary in great measure from each other, and then video settings are a must, but in video consoles is not nearly as necessary and that kind of settings is in general, almost non existing.

5.3.5 Effectiveness of heuristics in terms of number of specific usability problems identified

The effectiveness of the new set can be also evaluated by its capacity to detect specific usability problems related to the application particular features or aspects. The effectiveness of heuristics in terms of number of specific usability problems identified is calculated as follows:

$$Effectiveness (ESS) = \frac{Number\ of\ specific\ playability\ problems\ identified}{Total\ of\ playability\ problems\ identified} \times 100\% \quad (1)$$

Then we will say that ESS_1 and ESS_2 will be the effectiveness of the new FPS set, and the control set respectively. According to the methodology of Daniela Quiñones and Cristian Rusu [27], when ESS_1 is greater than ESS_2 the new heuristics works well.

Table 16: Effectiveness of heuristics in terms of number of specific usability problems identified

Heuristic Set	Number of specific usability problems identified	Total of Problems Found	Effectiveness
Game Heuristics	3	15	20%
FPS Heuristics	7	25	28%

In this case the new set has an effectiveness of the 28% compared the 20% of the control set (see table 16, presenting a discrete increase of eight percent. According to this result the new heuristic was able to obtain more specific problems, but in general this particular case study has more fundamental problems as a game, not only as a First Person Shooter, and both heuristics detected many of them.

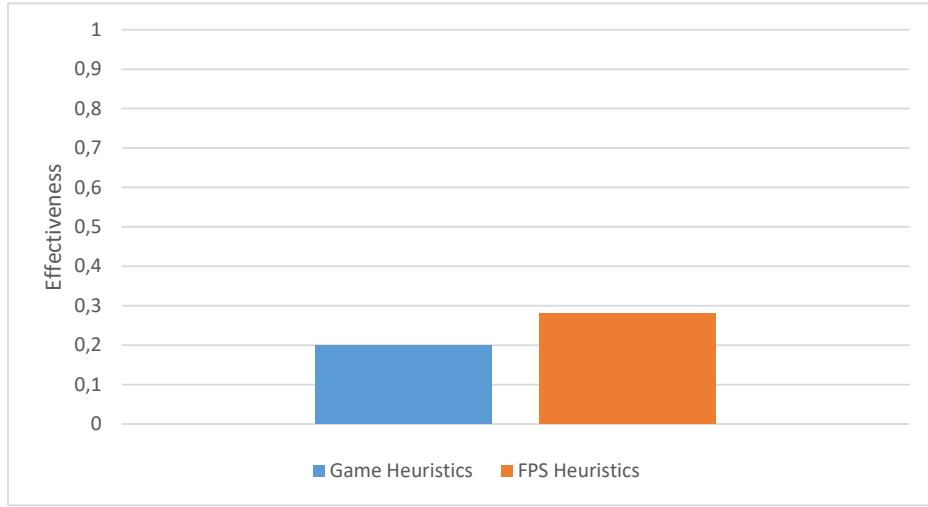


Figure 9: Effectiveness of heuristics in terms of number of specific usability problems identified

5.3.6 Effectiveness of heuristics in terms of usability problems identified as more severe

Once the duplicated problems were removed and the analysis of the number of problems was made, the two list of problems were sent to the experts to be evaluated in terms of its frequency and severity, using the scale shown in table 18, that ranges from zero to four. In this case, the effectiveness is focused on severity, as more severe problems can hinder the normal functioning of the application. Because the scale goes from zero to four, every problem with a severity greater than two would be qualified as "more severe" as this corresponds to the average value of the scale. Finally, the effectiveness of heuristics in terms of usability problems identified as more severe (ESV), will be calculated as follows:

$$Effectiveness (ESV) = \frac{Number\ of\ problems\ identified\ qualified\ with\ a\ severity\ greater\ than\ 2}{Total\ of\ playability\ problems\ identified} \times 100\% \quad (2)$$

Then we will say that $ESV1$ and $ESV2$ will be the effectiveness of the new FPS set, and the control set respectively.

Table 17: Effectiveness of heuristics in terms of the severity of the problems identified

Heuristic Set	Number of problems identified as severe	Total of Problems Found	Effectiveness
Game Heuristics	14	15	93%
FPS Heuristics	25	25	100%

In the results obtained, shown in table 17, the most notable aspect was the high severity the evaluators gave to the problems detected, only one of the 39 problems detected in total had a severity of two, the rest of them was considered as "more severe". This result is interesting in the sense that as was stated earlier, this game has fundamental flaws that makes it subjectively, hard to enjoy. But in terms of the effectiveness

of the heuristic sets, not much can be concluded.

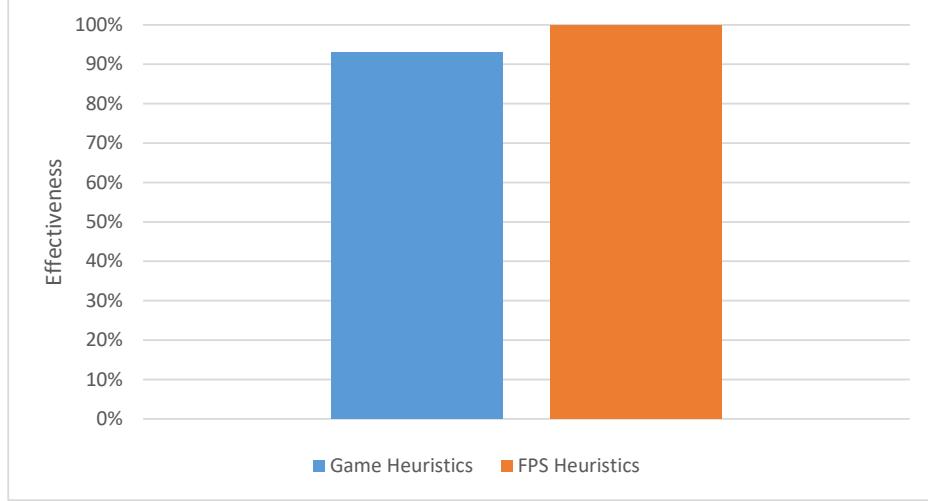


Figure 10: Effectiveness of heuristics in terms of the severity of the problems identified

Table 18: Rating scales of usability problems detected

Rating scale	Description	Values	Scale
Frequency	Rating indicating how often occurs the usability problem detected.	0-4	4: >90% 3: 51% to 90% 2: 11% to 50% 1: 1% to 10% 0: <1%
Severity	Rating indicating how catastrophic is the usability problem detected.	0-4	4: Catastrophic problem 3: Major problem 2: Minor problem 1: Cosmetic problem 0: Not a problem
Criticality	Sum of frequency and severity	0-8	-

5.3.7 Effectiveness of heuristics in terms of usability problems identified as more critical

This effectiveness is similar to the previous one, but focuses in the criticality of the problems, which is the sum of the frequency and severity of the problems (see table 18), and thus taking into account both of the dimensions in order to determine how critical the problem is. The scale of the criticality ranges from zero to eight, so is important to identify the problems with a criticality greater than four, as this is the average value of the scale. Finally, effectiveness of heuristics in terms of usability problems identified as more critical will be calculated as follows:

$$\text{Effectiveness (ESC)} = \frac{\text{Number of problems identified qualified with a criticality greater than 4}}{\text{Total of playability problems identified}} \times 100\% \quad (3)$$

Then we will say that $ESC1$ and $ESC2$ will be the effectiveness of the new FPS set, and the control set respectively.

Table 19: Effectiveness of heuristics in terms of the criticality of the problems identified

Heuristic Set	Number of problems identified as critical	Total of Problems Found	Effectiveness
Game Heuristics	15	15	100%
FPS Heuristics	25	25	100%

The results were quite similar to the ones obtained with the more severe problems. In this case both heuristics found problems that all experts considered critical, once again this is probably due to the abundance of big problems in the game. With this case of study, it can be concluded that both heuristics can detect severe problems, but the new set should have the edge as more problems were found using it.

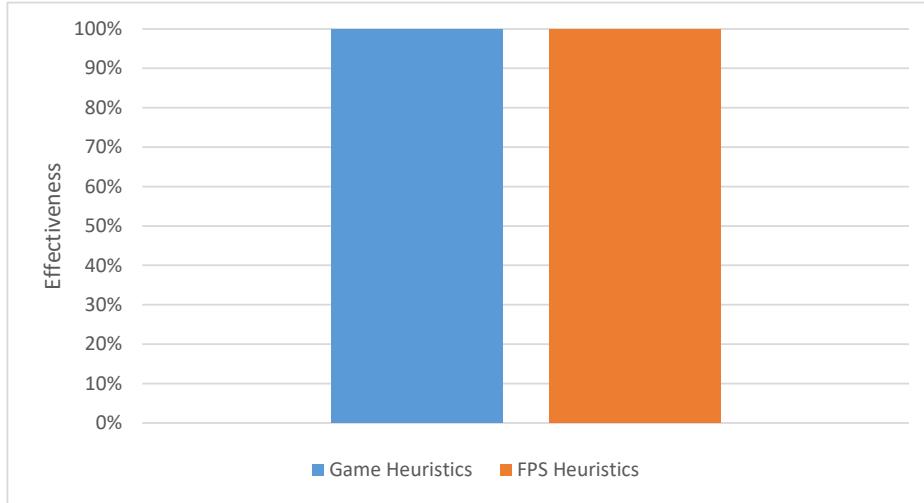


Figure 11: Effectiveness of heuristics in terms of the criticality of the problems identified

A final conclusion to the analysis of the effectiveness of both sets, is that it should be interesting to make another round of validations using a better rated game (a "better game"), to see if the heuristics can also detect problems in a more "harsh" environment. This qualifies as future work, as due to time and resource constraints would be impossible to make another heuristic evaluation of a more demanding game.

5.4 Results of the Expert Judgement

In the expert judgement, first we have the average of the grades assessed by the six experts on the four dimensions, which are shown in table 20. According to the methodology, an average of 3.7 or less for the utility dimension means that the heuristic are not perceived as useful by experts and require revision, and in that case, there are three heuristic that need revision, which will be detailed in section 6. Is worth noting that there are not problems with the clarity of the heuristics and the utility in general was perceived as good.

Table 20: Average of the results of the Expert Judgement, in yellow the averages lower than 3.7

ID	Name	Average Utility	Average Clarity	Average Ease of Use	Average Necessity of Examples
1	Feedback and Game Status	4,83	4,83	4,8	4,4
2	Aesthetic and Minimalist Design	4,67	4,83	4,8	4,2
3	Error Prevention	4,67	4,83	4,2	3,6
4	Controls and Responsiveness	4,67	4,83	4,2	3,8
5	Collision and Physics Consistency	4,00	4,50	4	3,8
6	Artificial Intelligence Engagement	4,67	4,50	4,4	4,4
7	Multiplayer Communication	4,50	4,33	4,2	4
8	Structure of Objectives and Pacing of the Game	3,67	4,67	4,4	3,8
9	Help and Tutorials	4,83	4,67	4,8	4,4
10	World Aesthetics, Rules and Mechanics Consistency	4,17	4,67	4	4,2
11	Curiosity, Challenges and Rewards	4,67	4,17	4	3,8
12	Emotional Stimuli	3,67	4,83	3,6	3,8
13	Socialization and Character Relationships	3,67	4,50	3,6	3,8
14	Difficulty and Game Fairness	4,33	4,50	4,6	4,4

5.5 Comments of Experts

The last piece of information obtained from the experiments, are the individual comments and recommendations of the experts that will be taken into consideration in some of the changes detailed in section 6. The comments are summarised in table 21.

Table 21: Summary of the comments of experts

ID	Name	Expert comment
3	Error Prevention	Is suggested to add to the heuristic what happens when the game enters in an error state, helping to recognize and recover from it.
4	Controls and Responsiveness	One expert suggest that this heuristic can be mistaken in the case of the online experience, because the increasing of input lag due internet connection issues.
11	Curiosity, Challenges and Rewards	One expert suggest that this heuristic can be mistaken with " <i>Difficulty and Game Fairness</i> " as both focuses in the challenge to the player.
12	Emotional Stimuli	Is stated that this aspect of a game is hard to evaluate due its subjective nature and that is not as important in these kind of games, compared to an Role Playing Game, for example.
13	Socialization and Character Relationships	Is stated that the character relationships are not that relevant in this kind of games and that is hard to evaluate.

6 Refinement of the New Set of Heuristics

In this section, and using the opinion of the experts and the data collected by the heuristic evaluation and surveys made in the previous section, the changes made to the initial set of heuristics will be reviewed and detailed.

6.1 Changes on Heuristic N°2 Aesthetic and Minimalist Design

One of the experts, during the heuristic evaluation, found icons in the game that were difficult to interpret, and there was not a specific heuristic covering that aspect. For this reason, in the definition and explanation of the heuristic N°2, *Aesthetic and Minimalist Design*, it was specified that the icons of the game should be meaningful and easy to interpret.

6.2 Changes to Heuristic N°3 Error Prevention

One expert found an error while playing and the game did not convey clearly that the game was in an error status, and the first version of the heuristic was not clear about what happened when the game entered in such status. For this reason the heuristic N°3 was renamed as *Prevention and Recognizement of Errors* and its definition and explanation was modified accordingly. One extra example was also added in this regard.

6.3 Changes to heuristic Heuristic N°4 Controls and Responsiveness

One expert said in his comments, that it was possible to mistake the lack of responsiveness with server or internet issues, so this was clarified accordingly in the explanation of the heuristic.

6.4 Changes to heuristic N°8 Structure of Objectives and Pacing of the Game

As can be seen in table 21, the average utility of this heuristic is 3.67, which according to the methodology means that needs revision. In this case, only some redaction modifications were performed, because only one expert rated its utility with a negative grade (with a two) while three experts rated it with a four or five. Another reason to not modify more the heuristic was that three problems were successfully linked to it and two of them were not found by the control group. Finally, this heuristic achieved good ratings (more than 4.4) in the dimensions of clarity and ease of use.

6.5 Changes to Heuristic N°12 Emotional Stimuli

It was decided to remove this heuristic for various reasons, first there is the low average in the utility dimension (3.67) and ease of use (3.6), then there were comments from the experts about the complexity on the evaluation of this aspect as is highly subjective and personal, opinion that the author agrees on and has a correlation with the low average in the ease of use dimension and finally, there were not problems correctly associated to this heuristic.

6.6 Changes to Heuristic N°13 Socialization and Character Relationships

This case is similar to the heuristic N°8 *Structure of Objectives and Pacing of the Game*, where three experts evaluated it with a five, one with a three and two with a two. There is also the fact that at least one problem was correctly associated to the heuristic and finally the author believes that *Socialization and Character Relationships* is indeed an important aspects of FPS games. For these reasons, only some adjustments to the redaction were performed.

7 Definition and Formalisation of the New Set of Heuristics

In this section the final version of the new set of heuristics is presented, even if the first formalisation was made before the validation, here it will be detailed how that process was. As it was said in section 4, in order to formalise the definition of the new set, the template (see table 1) proposed by the methodology Daniela Quiñones and Cristian Rusu [27] will be used. From all the components of this template, the priority (the numerical importance of the heuristics from one to where one is useful, two is important and three is critical), the name, the definition and explanation are included as the methodology strongly suggest it. Beside these four elements, is also used the Examples of the heuristic violation and compliance, in order to make it more easy to understand. The use of a checklist is also being considered, in the case of being necessary.

Most of the examples given, are positive and extracted from the games Overwatch [5] from Blizzard and Metro Last Light from 4A Games [6]. The first one, launched in May 2016, currently is one of the most popular online games with \$565 million in sales on personal computers along by the end of 2016, making it the highest revenue-generating non-free-to-play game for personal computers in that year. In the opinion of the author, one of the key of its success is the care of the developers to the Playability and Player Experience, making this game a perfect example of good practices. The second game, Metro Last Light is a good exponent of an singleplayer game, with focus in its atmosphere, world design, tone, graphics, and gameplay.

Table 22: Heuristic N°1 Feedback and Game Status

ID	1
Priority	3
Name	Feedback and Game Status
Definition	The game gives immediate and consistent feedback to the player's actions and game events.
Explanation	The game should give the player all the information he need about the immediate impact of his actions and considering the criticality of this information more than one channel should be used, like music, sound and visual effects or controller vibration. In the case of the game status, it should be clear, for example, when the game is loading.
Examples	In the game <i>Overwatch</i> when a shot lands on target, there are specific visual and sound effects depending on where it landed (body or head) or if it the target died with that last action. (See figure 12).



Figure 12: Visual hit indicator in *Overwatch*. From top to bottom: (1) single hit, (2) headshot and (3) kill, which are accompanied with their respective sound effects.



Figure 13: Typical view of the player during gameplay on *Overwatch*: (1) Time and objective status, (2) Player chat, (3) Current character and hit points, (4) Ultimate ability status, (5) Recent kills, (6) Ammunition and abilities status, (7) Teammates, (8) Current objective.

Table 23: Heuristic N°2 Aesthetic and Minimalist Design

ID	2
Priority	3
Name	Aesthetic and Minimalist Design
Definition	The user interface of the game, including all the different menus, shows all the information the player needs in a clean, clear, non-intrusive and visually pleasant way. The icons used are meaningful and easy to interpret.
Explanation	In order to achieve the game objectives, the player needs precise information, that needs to be conveyed clearly, without obstructing the field of view of the player nor hinder the aiming capabilities of the player. In the case of menus, these should be clear and precise, not overwhelming to the player with many different options. Icons should be simple and clear, making them easy to interpret and should follow the industry standards.
Examples	During gameplay, in <i>Overwatch</i> a lot of information is conveyed without cluttering the interface: In the top centre there is the current objective, the remaining time, and the status of that objective. On the right corner is shown when a player died and by who. On the left is the chat and more to the centre, some status of the abilities of the character is shown. In the left corner is the current character of the player and its hit points, in the bottom middle is the loading indicator of the ultimate ability of the character. In the right corner there are icons that represent the character abilities (with their current key mapping) and the ammunition remaining. And finally the position of the rest of the teammates can be always seen (see figure 13).

Table 24: Heuristic N°3 Prevention and Recognition of Errors

ID	3
Priority	3
Name	Prevention and Recognition of Errors
Definition	The player should not be able to make irreversible errors and the game should help the player recognise and recover from an eventual error state.
Explanation	During a normal gameplay session, the player should not enter in undesired states or unintended areas, provoke errors or make the game crash. Because these errors, the player may not be able to continue with the current objectives or they can even be used to complete them in unintended and unfair ways (the called exploits). It should also be conveyed clearly to the player when the game is in an error state, and how to recover through understandable messages and icons.
Examples	For example in <i>Battlefield 1</i> we see more than one player on the back of a horse. (See figure 14), and the connection error in <i>Overwatch</i> is shown in figure 15



Figure 14: One example of an unintended state on *Battlefield 1*.



Figure 15: One example of an error message on *Overwatch*.

Table 25: Heuristic N°4 Controls and Responsiveness

ID	4
Priority	3
Name	Controls and Responsiveness
Definition	The game should follow the industry conventions in the control mapping, respond consistently and with imperceptible delay (being <i>responsive</i>) between the action of the player and the reaction in the game.
Explanation	The mappings of the game should be similar to other games of the genre and offer customisation options and sensibility adjustments. And the delay between the player pressing a button in his input device (like the keyboard or gamepad) and the reaction of the character should be imperceptible. Is important to note that should not be mistook with server or connection issues that can be similar to control problems.
Examples	There are several examples of games that launched with noticeable input lag, one of the latest one is Bethesda's <i>Prey</i> [9] where in the Playstation 4 version suffered from this issue and was noted by players[10]. About the key mappings <i>Overwatch</i> is a good example of it, using common buttons mappings like "Q" "E" or "Shift" for the main actions (besides shooting) but besides that, it offers complete customisation in that regard.

Table 26: Heuristic N°5 Collision and Physics Consistency

ID	5
Priority	2
Name	Collision and Physics Consistency
Definition	The collision and physic systems are fair and consistent on its execution through the game.
Explanation	The collision and physics systems are tightly connected as they are the responsible to handle, for example, the projectiles trajectory and penetration capabilities, or the effects of gravity on how the characters move. These systems should be in concordance with the aesthetics and world presented on the game, so if is it a war simulator, the player expect a high level of realism in this sense.
Examples	On <i>Battlefield 1</i> , a war game set on the first World War, on long distance shots the player must take in account the effect of gravity in the trajectory of the projectile and the relative movement of the target, besides the game presents a fairly realistic destruction models on the infrastructure.



Figure 16: On *Battlefield 1*, in long distance shots the player must compensate the effect of gravity and the relative movement of the target.

Table 27: Heuristic N°6 Artificial Intelligence Engagement

ID	6
Priority	2
Name	Artificial Intelligence Engagement
Definition	The behaviour, and for extension, the artificial intelligence (AI) on enemies should be engaging and interesting, in allies should not hinder the progress of the player.
Explanation	The AI on enemies should offer a challenge consequent to the selected difficulty, they should use the environment to their advantage and use tactics against the player, but without feeling cheap (killing the player in one shot for example). In the case of allies, they should follow the player and don't restrain his progress. Stuck AI-controlled character must be avoided.
Examples	In <i>F.E.A.R</i> [7], a game developed by Monolith Productions on 2005, even if it was launched more than 10 years ago, is still considered an exponent in this area [8]. Enemies can duck to travel under crawlspaces, jump through windows, vault over railings, climb ladders, and push over large objects to create cover. Various opponents may act as a team, taking back routes to surprise the player, using suppressive fire or taking cover if under fire.

Table 28: Heuristic N°7 Multiplayer Communication

ID	7
Priority	2
Name	Multiplayer Communication
Definition	If there is a multiplayer mode, the game should provide multiple and adequate tools to allow players communicate with each other.
Explanation	If the game offers a multiplayer mode, it should provide to the player different ways to communicate each other, as a minimum a text-based chat and a voice one. In the case of the later one, the game should considerate ways to deactivate them, or mute specific players if the user wants to.
Examples	In <i>Overwatch</i> , a game that revolves around multiplayer interaction, are offered three ways of communication: A simple chat, a voice chat (see image 18) and a wheel with some commonly used commands (see image 17).



Figure 17: Quick options to commonly used commands on *Overwatch*.



Figure 18: Voice chat in *Overwatch*.

Table 29: Heuristic N°8 Structure of Objectives and Pacing of the Game

ID	8
Priority	2
Name	Structure of Objectives and Pacing of the Game
Definition	The game shows clearly its objectives, structures and paces them in order to keep the player's attention but not to overwhelm or frustrate him.
Explanation	The game should pace its objectives relative to the capabilities of the player, so they should start with few and easy ones and then, when the player has more skills, these are increased in number and difficulty, but without overwhelming or leaving him with nothing to do.
Examples	In the game <i>Metro Last Light</i> , the first minutes of gameplay the player has access to a sort of "sandbox" where can explore the functioning of different weapons and instruments, and then is presented with the first challenges as he adventures outside of this "sandbox".

Table 30: Heuristic N°9 Help and Tutorials

ID	9
Priority	2
Name	Help and Tutorials
Definition	The game offers tutorials if needed, helping the less skilled players, but not boring the expert ones and employs different approaches to teach new concepts and mechanics. The game also should exploit the previous knowledge of the player about similar games.
Explanation	There are many ways to teach the concepts and mechanics to a new player, and the game should offer different options to different kinds of players: There is high probability that is not the player's First Person Shooter, and for this reason the tutorial should be optional, skippable or very short, but for new players should teach all the essentials.
Examples	In <i>Metro Last Light</i> in the beginning of the game there is a shooting range where the player can shot practice targets with different weapons (See figure 19). In <i>Overwatch</i> there are three different training modes a tutorial, a shooting range and an AI practice match, where players can play the game without consequences (See figure 20) and also gives contextual help during gameplay about the current character the player is using (See figure 21).



Figure 19: *Metro Last Light* shooting range.



Figure 20: Training modes in *Overwatch*.



Figure 21: Contextual help in *Overwatch*.

Table 31: Heuristic N°10 World Aesthetics, Rules and Mechanics Consistency

ID	10
Priority	2
Name	World Aesthetics, Rules and Mechanics Consistency
Definition	The world presented should be believable in an aesthetic sense and consistent with the rules, mechanics and scenarios of the game. The player also should be aware of the consequences of his actions in this world.
Explanation	There should be a correlation between the aesthetics, rules, mechanics and scenarios of the game in order to help each other to convey a believable world. There should be a reason in the world presented that supports the mechanics and rules, in a way that don't challenge the suspension of disbelief of the player. And the player should be aware that his actions will have consequences in the world.
Examples	<i>Metro Last Light</i> , presents a world were there was a nuclear war, which left the surface of the Earth uninhabitable due to the radiation, leaving humanity renegade to underground systems fighting against mutated creatures product of the radiation. This setting is the basis to all the rules of the game, the enemies, how characters live and interact with each other, the scarcity of bullets and good weapons and so on. All of this is also enhanced by the visual presentation.



Figure 22: An example of how the visual enhances and complements the world presented in *Metro Last Light*.

Table 32: Heuristic N°11 Curiosity, Challenges and Rewards

ID	11
Priority	2
Name	Curiosity, Challenges and Rewards
Definition	The game promotes the curiosity of the gamer, allowing him to improve his abilities and presents diverse challenges that reward the player consistently to the effort made to overcome them.
Explanation	The game should promote the curiosity of the gamer, rewarding him when he explores the world in places different than the main objective. Presenting different and optional objectives or challenges that enhances the diversity and reduces the monotony, adding more content for the players who wants to invest more time in the game.
Examples	In <i>Metro Last Light</i> there is a compass that indicates clearly where the main objective is, but if the players see something interesting off route, he can be rewarded with more ammunition or more information in the form of hidden documents which present more information about the world in which the game is set.

Table 33: Heuristic N°12 Socialization and Character Relationships

ID	12
Priority	2
Name	Socialization and Character Relationships
Definition	In multiplayer games, the player should be conscious of being part of a team. In single player, the relationship between the player's avatar and other characters should be meaningful.
Explanation	In the case of multiplayer games, the player should be conscious of being part of a team and hence, rules, challenges and objectives should be developed in order to raise the player's awareness of their role in the success of the group. In single player, the relationship between the player's avatar and other characters should be meaningful, ideally important non-playable characters (NPC) should have a clear role in the world.
Examples	In <i>Overwatch</i> the player can see his performance compared to the rest of the teammates and is rewarded with medals (see figure 23) when he accomplish in good measure the function of his character, encouraging him to do his best to achieve gold medals or the "Play of the match".



Figure 23: Summary of the player's performance after a match on *Overwatch*

Table 34: Heuristic N°13 Game Fairness and Difficulty

ID	13
Priority	2
Name	Difficulty and Game Fairness
Definition	The game is fair and the player understand the rules of the games, which present different difficulty levels.
Explanation	The rules should be clear to the player, how to beat the current challenge, the ways his character can die and so on. The game should be fair in the sense that a challenge can be beaten if the player improves or uses better tactics. Is noteworthy that there is a thin between being true difficulty that motivates the player to improve and cheap one, that only frustrates him. The game also should present different difficulty levels to appeal to different play-styles.
Examples	In <i>Metro Last Light</i> there are two different Play Styles (see image 24) to appeal two different kind of player, the ones who wants to experience the story of the game more casually, and the ones who want a challenge enhancing the survival aspects of the game. This game also supports four different difficulties (see image 25), in order to further adjust the difficulty level.

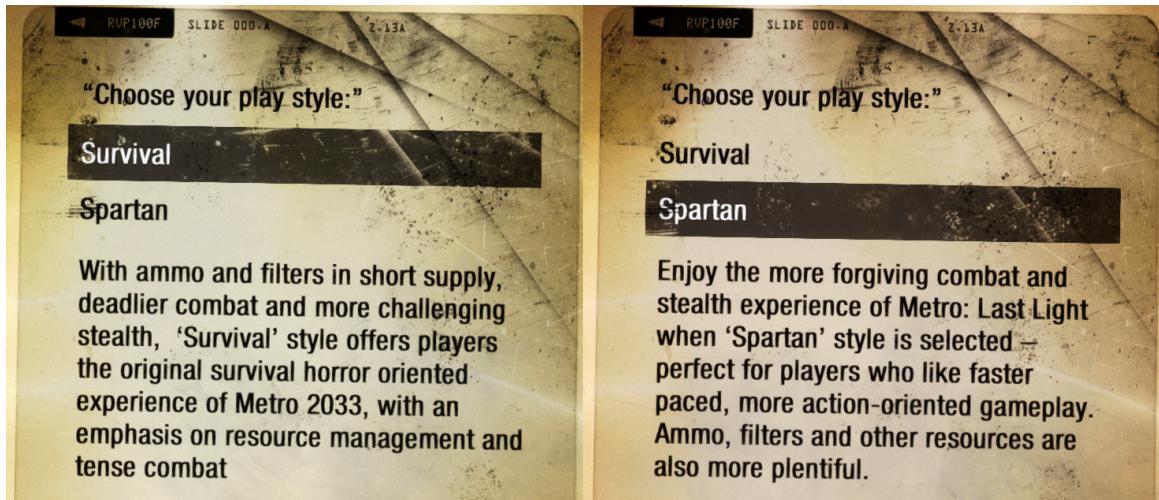


Figure 24: Different play styles offered in *Metro Last Light*

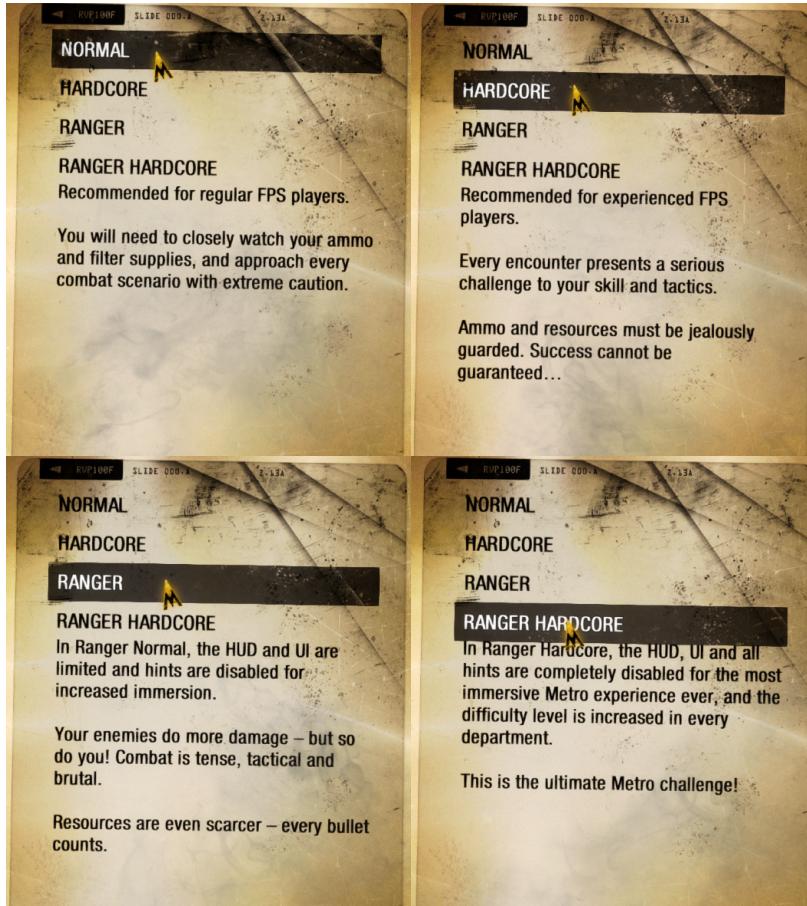


Figure 25: Difficulty selection on *Metro Last Light*

8 Conclusions and Future Work

In this document can be appreciated that video games are a relevant market and that First Person Shooters are among the most popular genres. Video games are also an important segment of the interactive software, even so that has a whole branch of investigation focused only on them, where the need of specific terms like Playability and Player Experience emerged out of the necessity to cover its specifics nuances. Another important topic in this document, is the difficulty in the detection of potential problems that can hinder the Player Experience, due its highly subjective nature, that depends heavily in who is playing. To perform this task is proposed the creation of a specific set Playability/User Experience Heuristics to help in the detection of problems in those areas.

In order to develop the first version of the new set, various sources of information were used, the first one were be the most relevant characteristics and needs of FPS games, like responsive controls, advanced artificial intelligence of enemies and allies among others. The second source were the Playability model of González et al. and Player Experience Model Core Elements of the Gaming Experience (CEGE). With that information, various prototype of heuristics where created and then compared to the studied and currently available heuristic sets, in order to determine if one covered all the important subjects, but as none contemplated them all, a new set was created.

Using the template given by the work methodology of Daniela Quiñones and Cristian Rusu, the initial formalisation of the new set of heuristics was made, then, a first round of validation and refinement was performed, in which the new set was compared to an existing and more generic one using the heuristic evaluation and the expert judgement. Using the raw data from these experiments, invaluable information was extracted, from comments of the experts to the effectiveness in various aspects of the new set. It was thanks to this external information that many rough edges were smoothed out.

Finally, the development of this work was constrained heavily by time and resources, especially in the latter one, as to perform heuristic evaluations is not only needed the already scarce experts, but due the nature of games, they require special hardware (i.e. a relatively powerful computer) to be tested in ideal conditions, and not even taking into account the price of newer games. All those reasons make quite difficult to do these experiments. For this reason, in future instalments of this work, new test cases should be found, specially "better" games, in order to make a second iteration to validate even further the capabilities of the new heuristic set.

References

- [1] How long to beat. "<https://howlongtobeat.com/>". Online, accessed 03 may 2017.
- [2] Gameloft main site. "<http://www.gameloft.com/es/>". Online, accessed 12 October 2017.
- [3] Usability First glossary. "<http://www.usabilityfirst.com/glossary/playability/>". Online, accessed 25 march 2017.
- [4] SteamSpy - All the data and stats about Steam games. "<https://steamspy.com/>". Online, accessed 30 May 2017.
- [5] Overwatch official website. "<https://playoverwatch.com/es-es/>". Online, accessed 30 May 2017.
- [6] Metro Last Light official website. "<http://www.metrothegame.com/en-gb/>". Online, accessed 30 May 2017.
- [7] F.E.A.R official website. "<http://www.lith.com/Games/F-E-A-R->". Online, accessed 30 May 2017.
- [8] Assaulting F.E.A.R.'s AI: 29 Tricks to Arm Your Game. "<http://aigamedev.com/open/review/fear-ai/>". Online, accessed 30 May 2017.
- [9] Prey's official website. "<https://prey.bethesda.net/es/>". Online, accessed 30 May 2017.
- [10] Reddit topic about the high input lag on Prey. "https://www.reddit.com/r/prey/comments/69s3cr/input_lag/". Online, accessed 30 May 2017.
- [11] Ernest Adams. *Fundamentals of Game Design*. New Riders, 2009.
- [12] Entertainment Software Association. *Essential Facts about the computer and video game industry*. "<http://essentialfacts.theesa.com/mobile/>", 2017. Online, accessed 26 march 2017.
- [13] Regina Bernhaupt. *User Experience Evaluation in Entertainment*, pages 3–7. Springer London, London, 2010.
- [14] Emily Brown and Paul Cairns. A grounded investigation of game immersion. In *CHI '04 Extended Abstracts on Human Factors in Computing Systems*, CHI EA '04, pages 1297–1300, New York, NY, USA, 2004. ACM.
- [15] Eduardo H Calvillo-Gámez, Paul Cairns, and Anna L Cox. Assessing the core elements of the gaming experience. In *Game User Experience Evaluation*, pages 37–62. Springer, 2015.
- [16] Benjamin Cowley, Ilkka Kosunen, Petri Lankoski, J. Matias Kivikangas, Simo Järvelä, Inger Ekman, Jaakko Kemppainen, and Niklas Ravaja. Experience assessment and design in the analysis of gameplay. *Simulation & Gaming*, 45(1):41–69, 2014.

- [17] Heather Desurvire, Martin Caplan, and Jozsef A Toth. Using heuristics to evaluate the playability of games. In *CHI'04 extended abstracts on Human factors in computing systems*, pages 1509–1512. ACM, 2004.
- [18] Heather Desurvire and Charlotte Wiberg. Game usability heuristics (play) for evaluating and designing better games: The next iteration. In *International Conference on Online Communities and Social Computing*, pages 557–566. Springer, 2009.
- [19] International Organization for Standardization. Human-centered design for interactive systems. *Ergonomics of human system interaction*, 2009.
- [20] Roberto Hernández Sampieri, Carlos Fernández Collado, and Pilar Baptista Lucio. Metodología de la investigación. *La Habana: Editorial Félix Varela*, 2, 2003.
- [21] Hannu Korhonen and Elina MI Koivisto. Playability heuristics for mobile games. In *Proceedings of the 8th conference on Human-computer interaction with mobile devices and services*, pages 9–16. ACM, 2006.
- [22] Florian’Floyd’ Mueller, Darren Edge, Frank Vetere, Martin R Gibbs, Stefan Agamanolis, Bert Bongers, and Jennifer G Sheridan. Designing sports: a framework for exertion games. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 2651–2660. ACM, 2011.
- [23] Jakob Nielsen and Rolf Molich. Heuristic evaluation of user interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 249–256. ACM, 1990.
- [24] David Pinelle, Nelson Wong, and Tadeusz Stach. Heuristic evaluation for games: usability principles for video game design. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pages 1453–1462. ACM, 2008.
- [25] David Pinelle, Nelson Wong, and Tadeusz Stach. Using genres to customize usability evaluations of video games. In *Proceedings of the 2008 Conference on Future Play: Research, Play, Share, Future Play ’08*, pages 129–136, New York, NY, USA, 2008. ACM.
- [26] K Poels, YAW de Kort, and WA Ijsselsteijn. Fuga-the fun of gaming: Measuring the human experience of media enjoyment. deliverable d3. 3: Game experience questionnaire. *FUGA project*, 2008.
- [27] Daniela Quiñones and Cristian Rusu. Methodology to develop usability/user experience heuristics. Pontificia Universidad Católica de Valparaíso.
- [28] Miguel Sicart. Defining game mechanics. *Game Studies*, pages 1604–7982, 2008.
- [29] Jeff Sinclair, Philip Hingston, and Martin Masek. Exergame development using the dual flow model. In *Proceedings of the Sixth Australasian Conference on Interactive Entertainment*, page 11. ACM, 2009.
- [30] Penelope Sweetser and Peta Wyeth. Gameflow: A model for evaluating player enjoyment in games. *Comput. Entertain.*, 3(3):3–3, July 2005.

- [31] José Luis González Sánchez, Francisco Luis Gutiérrez Vela, Francisco Montero Simarro, and Natalia Padilla-Zea. Playability: analysing user experience in video games. *Behaviour & Information Technology*, 31(10):1033–1054, 2012.
- [32] Josef Wiemeyer, Lennart Nacke, Christiane Moser, and Florian ‘Floyd’ Mueller. *Player Experience*, pages 243–271. Springer International Publishing, Cham, 2016.
- [33] Mingmin Zhang, Mingliang Xu, Yong Liu, Gaoqi He, Lizhen Han, Pei Lv, and Yongqing Li. The framework and implementation of virtual network marathon. In *VR Innovation (ISVRI), 2011 IEEE International Symposium on*, pages 161–167. IEEE, 2011.

Appendices

A Sets of heuristics

Table 35: Heuristics for Evaluating Playability (HEP), developed by Desurvire et al.

Nº	Game Play
1	Player's fatigue is minimized by varying activities and pacing during game play.
2	Provide consistency between the game elements and the overarching setting and story to suspend disbelief.
3	Provide clear goals, present overriding goal early as well as short-term goals throughout play.
4	There is an interesting and absorbing tutorial that mimics game play.
5	The game is enjoyable to replay.
6	Game play should be balanced with multiple ways to win.
7	Player is taught skills early that you expect the players to use later, or right before the new skill is needed.
8	Players discover the story as part of game play.
9	Even if the game cannot be modeless, it should be perceived as modeless.
10	The game is fun for the Player first, the designer second and the computer third. That is, if the non-expert player's experience isn't put first, excellent game mechanics and graphics programming triumphs are meaningless.
11	Player should not experience being penalized repetitively for the same failure.
12	Player's should perceive a sense of control and impact onto the game world. The game world reacts to the player and remembers their passage through it. Changes the player makes in the game world are persistent and noticeable if they back-track to where they've been before.
13	The first player action is painfully obvious and should result in immediate positive feedback.
14	The game should give rewards that immerse the player more deeply in the game by increasing their capabilities (power-up), and expanding their ability to customize.
15	Pace the game to apply pressure but not frustrate the player. Vary the difficulty level so that the player has greater challenge as they develop mastery. Easy to learn, hard to master.
16	Challenges are positive game experiences, rather than a negative experience (results in their wanting to play more, rather than quitting).
Nº	Game Story
1	Player understands the story line as a single consistent vision.
2	Player is interested in the story line. The story experience relates to their real life and grabs their interest.
3	The Player spends time thinking about possible story outcomes.
4	The Player feels as though the world is going on whether their character is there or not.
5	The Player has a sense of control over their character and is able to use tactics and strategies.
6	Player experiences fairness of outcomes.
7	The game transports the player into a level of personal involvement emotionally (e.g., scare, threat, thrill, reward, punishment) and viscerally (e.g., sounds of environment).
8	Player is interested in the characters because (1) they are like me; (2) they are interesting to me, (3) the characters develop as action occurs.
Nº	Mechanics
1	Game should react in a consistent, challenging, and exciting way to the player's actions (e.g., appropriate music with the action).
2	Make effects of the Artificial Intelligence (AI) clearly visible to the player by ensuring they are consistent with the player's reasonable expectations of the AI actor.
3	A player should always be able to identify their score/status and goal in the game.
4	Mechanics/controller actions have consistently mapped and learnable responses.
5	Shorten the learning curve by following the trends set by the gaming industry to meet user's expectations.
6	Controls should be intuitive, and mapped in a natural way; they should be customizable and default to industry standard settings.
7	Player should be given controls that are basic enough to learn quickly yet expandable for advanced options.
Nº	Usability
1	Provide immediate feedback for user actions.
2	The Player can easily turn the game off and on, and be able to save games in different states.
3	The Player experiences the user interface as consistent (in control, color, typography, and dialog design) but the game play is varied.
4	The Player should experience the menu as a part of the game.
5	Upon initially turning the game on the Player has enough information to get started to play.
6	Players should be given context sensitive help while playing so that they do not get stuck or have to rely on a manual.
7	Sounds from the game provide meaningful feedback or stir a particular emotion.
8	Players do not need to use a manual to play game.
9	The interface should be as non-intrusive to the Player as possible.
10	Make the menu layers well-organized and minimalist to the extent the menu options are intuitive.
11	Get the player involved quickly and easily with tutorials and/or progressive or adjustable difficulty levels.
12	Art should be recognizable to player, and speak to its function.

Table 36: Examples of some questions guided by Facets used by PHET, developed by González et al.

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

Table 37: Play Heuristics, category 1: Game Play, by H. Desurvire and C. Wiberg

I. Category 1: Game Play	
A. Heuristics: Enduring Play	
A1	The players finds the game fun, with no repetitive or boring tasks.
A2	The players should not experience being penalized repetitively for the same failure.
A3	The players should not lose any hard won possessions.
A4	Gameplay is long and enduring and keeps the players' interest.
A5	Any fatigue or boredom was minimized by varying activities and pacing during the game play.
B. Heuristics: Challenge, Strategy and Pace	
B1	Challenge, strategy and pace are in balance
B2	The game is paced to apply pressure without frustrating the players. The difficulty level varies so the players experience greater challenges as they develop mastery.
B3	Easy to learn, harder to master.
B4	Challenges are positive game experiences, rather than negative experiences, resulting in wanting to play more, rather than quitting.
B5	AI is balanced with the players' play.
B6	The AI is tough enough that the players have to try different tactics against it.
C. Heuristic: Consistency in Game World	
C1	The game world reacts to the player and remembers their passage through it.
C2	Changes the player make in the game world are persistent and noticeable if they back-track to where they have been before.
D. Heuristic: Goals	
D1	The game goals are clear. The game provides clear goals, presents overriding goals early as well as short term goals throughout game play.
D2	The skills needed to attain goals are taught early enough to play or use later, or right before the new skill is needed.
D3	The game gives rewards that immerse the player more deeply in the game by increasing their capabilities, capacity or for example, expanding their ability to customize.
E. Heuristic: Variety of Players and Game Styles	
E1	The game supports a variety of game styles.
E2	The game is balanced with multiple ways to win.
E3	The first ten minutes of play and player actions are painfully obvious and should result in immediate and positive feedback for all types of players.
E4	The game had different AI settings so that it was challenging to all levels of players, whether novice or expert players.
F. Heuristic: Players Perception of Control	
F1	Players feel in control.
F2	The player's have a sense of control and influence onto the game world.

Table 38: Play Heuristics, Category 2: Coolness/Entertainment/Humor/Emotional Immersion by H. Desurvire and C. Wiberg

II. Category 2: Coolness/Entertainment/Humor/Emotional Immersion	
A. Heuristics: Emotional Connection	
A1	There is an emotional connection between the player and the game world as well as with their “avatar.”
B. Heuristics: Coolness/Entertainment	
B1	The game offers something different in terms of attracting and retaining the players’ interest.
C. Heuristic: Humor	
C1	The game uses humor well.
D. Heuristic: Immersion	
D1	The game utilizes visceral, audio and visual content to further the players’ immersion in the game.

Table 39: Play Heuristics, Category 3: Usability & Game Mechanics by H. Desurvire and C. Wiberg

I. Category 3: Usability & Game Mechanics	
A. Heuristics: Documentation/Tutorial	
A1	Player does not need to read the manual or documentation to play.
A2	Player does not need to access the tutorial in order to play.
B. Heuristics: Status and Score	
B1	Game controls are consistent within the game and follow standard conventions.
B2	Status score Indicators are seamless, obvious, available and do not interfere with game play.
B3	Controls are intuitive, and mapped in a natural way; they are customizable and default to industry standard settings.
B4	Consistency shortens the learning curve by following the trends set by the gaming industry to meet users' expectations. If no industry standard exists, perform usability/playability research to ascertain the best mapping for the majority of intended players.
C. Heuristic: Game Provides Feedback	
C1	Game provides feedback and reacts in a consistent, immediate, challenging and exciting way to the players' actions.
C2	Provide appropriate audio/visual/visceral feedback (music, sound effects, controller vibration).
D. Heuristic: Terminology	
D1	The game goals are clear. The game provides clear goals, presents overriding goals early as well as short term goals throughout game play.
D2	The skills needed to attain goals are taught early enough to play or use later, or right before the new skill is needed.
D3	The game gives rewards that immerse the player more deeply in the game by increasing their capabilities, capacity or, for example, expanding their ability to customize.
E. Heuristic: Burden On Player	
E1	The game does not put an unnecessary burden on the player.
E2	Player is given controls that are basic enough to learn quickly, yet expandable for advanced options for advanced players.
F. Heuristic: Screen Layout	
F1	Screen layout is efficient, integrated, and visually pleasing.
F2	The player experiences the user interface as consistent (in controller, color, typographic, dialogue and user interface design).
F3	The players experience the user interface/HUD as a part of the game.
F4	Art is recognizable to the player and speaks to its function.
G. Heuristic: Navigation	
G1	Navigation is consistent, logical and minimalist.
H. Heuristic: Error Prevention	
H1	Player error is avoided.
H2	Player interruption is supported, so that players can easily turn the game on and off and be able to save the games in different states.
H3	Upon turning on the game, the player has enough information to begin play.
H4	Players should be given context sensitive help while playing so that they are not stuck and need to rely on a manual for help.
H5	All levels of players are able to play and get involved quickly and easily with tutorials, and/or progressive or adjustable difficulty levels.
I. Heuristic: Game Story Immersion	
I1	Game story encourages immersion (If game has story component).

Table 40: Core Elements of the Gaming Experience Questionnaire (CEGEQ), Calvillo-Gámez et al

Scale	Questions
Enjoyment	I enjoyed playing the game I liked the game I would play this game again
Frustration	I was frustrated at the end of the game I was frustrated whilst playing the game
Puppetry: Control	I was in control of the game The controllers responded as I expected I remember the actions the controllers performed I was able to see in the screen everything I needed during the game I knew what I was supposed to do to win the game I knew all the actions that could be performed in the game There was time when I was doing nothing in the game The point of view of the game that I had spoiled my gaming
Puppetry: Facilitators	I liked the way the game look The graphics of the game were plain I do not like this type of game I got bored playing this time I usually do not choose this type of game
Puppetry: Ownership	I did not have a strategy to win the game The game kept constantly motivating me to keep playing I felt what was happening in the game was my own doing I felt guilty for the actions in the game I challenged myself even if the game did not require it I played with my own rules
Puppetry: Control/Ownership	I knew how to manipulate the game to move forward
Video-Game: Environment	The graphics were appropriate for the type of game The sound effects of the game were appropriate I did not like the music of the game The graphics of the game were related to the scenario The graphics and sound effects of the game were related The sound of the game affected the way I was playing
Video-Game: Game-Play	The game was unfair I understood the rules of the game The game was challenging The game was difficult The scenario of the game was interesting I did not like the scenario of the game

B Lists of Playability/Player Experience problems found with the new and control sets of heuristics

Table 41: List of Playability/Player Experience problems found with the new set of heuristics

Id	Definición del problema	Comentarios/Explicaciones	Ejemplos de ocurrencia	Heurística Incumplida
1	Indicaciones demasiado rápidas	La explicación de las misiones en la etapa pasan demasiado rápido, sin alcanzar a leerlas bien	Al iniciar una etapa	1
2	No se entiende instrucción	En una sección del juego se indica una flecha hacia abajo, pero lo que se quiere en el fondo es que el jugador avance hasta dicha flecha	En la primera etapa del juego	3
3	Indicación poco clara	Se indican flechas, pero se deben deslizar rápidamente, además no es lo más adecuado para notebook, si no que más bien para la versión móvil del juego	En la primera etapa del juego	4
4	Sin información sobre opción de cambiar el arma	En el juego se puede cambiar el arma pero no se indican las características de este si es que es mejor o peor que la actual	En la primera etapa del juego	14
5	Apuntar al amigo	En el juego se puede apuntar al amigo, no se puede disparar pero si apuntar lo cuál no debería ocurrir	A lo largo de todo el juego	13
6	Figuras se pierden con fondo blanco	El fondo es blanco y las figuras también lo son, así que no se distingue.	En la segunda etapa del juego	2
7	Publicidad tapa información	La publicidad tapa información proporcionada por el juego	A lo largo de todo el juego	2
8	Opción para móviles, siendo que se esta en un notebook	El juego tiene su origen en dispositivo móvil y se adapta a notebook, pero a pesar de ello tiene opción de ajustar la pantalla táctil.	En ajustes	4
9	Control poco estándar	El control del juego no es estándar, esta enfocado para pantalla táctil	En la sección de elegir soldado.	4
10	Destaca una etapa para seleccionarla pero en otra dice continuar, no se aclara que hacer	Aparecen 3 opciones a seguir, en la segunda se destaca para seleccionarla, pero en la sección de abajo dice continuar, el usuario podría no saber cuál es la que efectivamente debe seguir	En la sección de cambiar etapa	8
11	El juego se queda cargando demasiado tiempo, sin dar respuesta al jugador	Al querer escribir un mensaje se queda cargando, siendo que en verdad no se puede ingresar debido a que no hay sesión iniciada. El juego debería dar una respuesta útil al jugador	En la sección de crear un mensaje	3
12	No permite escribir en cuadro que dice "Escribe tu mensaje aquí"	Al seleccionar cuadro para escribir un mensaje este no se habilita, siendo que el cuadro dice que es para escribir	En la sección de crear un mensaje	1
13	Funcionalidades no claras	El juego cuenta con "potenciadores" que no se saben lo que son pero que aparecen en el inicio del juego	pantalla de inicio del juego	1
14	El juego no avisa cuando el jugador esta perdiendo	Para jugadores sin experiencia, no se entiende en que momento el jugador se esta muriendo, simplemente avisa que se esta quedando sin energía e inmediatamente muere	En el transcurso de cualquier misión	1
15	No hay explicación en las misiones multiplayer	Debería mostrar algún tutorial con la explicación de las modalidades que tiene en multijugador.	Por lo menos al principio no sabía que había que "seguir una carga" o en otro modo no decía explícitamente que había que matar a tantos enemigos pudas.	9
16	No existe objetivo claro en multiplayer de forma explicita	Hace falta un objetivo claro en los modos de multijugador, porque sin un objetivo no hay un enganche en el juego y termina aburriente.	Las misiones en multiplayer no tienen un objetivo claro definido al principio	8

Table 42: List of Playability/Player Experience problems found with the new set of heuristics (cont.)

17	Existen errores al momento de jugar	Por lo menos en mi CPU el juego tiene algunos errores con respecto a como se ven las armas visualmente, algunas de las armas que dropean los personajes se bucean y quedan titilando sin poder recogerlas. En otra ocasión se me quedo apretada una tecla de dirección lo que dificulto el modo de multijugador.	Dentro del juego	3
18	No permite escuchar los pasos	Hay un problema con el sonido al escuchar o no los pasos del enemigo, entonces nunca sabes si esta cerca a menos que te dispare.	En todas las misiones	12
19	Problemas de diseño	El diseño que se muestra en los menús ofrece demasiada información, hostigando al usuario. Además no permite ver la vida de un jugador, ni la vida de nuestro jugador, lo que dificulta el modo de juego con respecto a saber en que momento cubrirse.	En el menú principal	2
20	No hay comunicación en modo multiplayer	No se puede comunicar entre los jugadores, lo cual dificulta el modo de juego limitando solamente a seguir a los demás.	En la sección multijugador	7
21	Mala física	Existe un problema al momento de disparar a la cabeza, el área es muy amplia lo que facilita tener la habilidad de hacer un head shot.	en todo el juego	5
22	Se rompe el ritmo de juego	el juego transcurre en mini misiones por lo cual no es lineal. Su constitución es similar a los juegos de móvil	en las misiones del juego	8
23	Sin capacidad penetración puerta papel	las balas no atraviesan las puertas con papel, sin embargo en instancias anteriores esto si era posible	cuando se dispara através de determinados puertas	5
24	Inteligencia artificial poco explorada	la inteligencia artificial esta pobemente desarrollada no existe interacción entre el jugador y el aliado, a parte de los comportamientos preprogramados	en todo el juego	6
25	Perdida de la mira o puntero en quick events	al realizar los quick events se pierde el puntero como resultado la reacción al mismo se vuelve mas lenta y confunde al usuario	quick events	10

Table 43: List of Playability/Player Experience problems found with the control set of heuristics

Id	Definición del problema	Comentarios/Explicaciones	Ejemplos de ocurrencia	Heurística Incumplida
1	Publicidad en menú de carga	Aparece publicidad de otros juegos en el menú de carga	cuando se realiza la cara de los niveles, y cuando se inicia el juego, impidiendo ver pantalla de inicio.	4
2	Configuración de video pobre	La configuración de video que presenta es bastante básica	No se pueden configurar características de mapas, escala de pantalla, velocidad de refresco de pantalla limitada.	2
3	Juego con energía	Cada misión gasta energía, lo cual no permite jugar el contenido completo sin antes recargar.	Niveles de juegos PVE	5
4	Sin capacidad penetración puerta papel	las balas no atraviesan las puertas con papel, sin embargo en instancias anteriores esto si era posible	cuando se dispara a través de determinados puertas	1
5	Los tutoriales no se pueden saltar	Cada vez que el videojuego quiere enseñar una nueva función o sección, obliga al jugador a realizar todos los pasos del tutorial, sin permitir la opción de saltarlo	Al enseñar los paquete de armas	1
6	perdida de puntería	A cierta distancia los disparos a la cabeza no son efectivos, por mas que se apunte a la cabeza del objetivo el disparo falla	en todo el juego	7
7	puntos ciegos	en ciertos puntos aunque el enemigo este frete a ti este no acierta disparos. Por interrupción de física de objetos invisibles del campo.	A lo largo del juego	1
8	No permite cambiar configuración de video hasta terminar las 2 primeras misiones.	El juego no permite cambiar los gráficos del juego, hasta que se termine el tutorial.	Al Jugar por primera vez	2
9	Mala IA	Los NPC se mueven de forma errática, son lentos, disparan a un sector fijo en vez de apuntar.	Los npc amigos "corren" más lento que el jugador caminando. Los enemigos al disparar no apunta al jugador, estuve 4 minutos en frente de 3 enemigos y no pudieron matarme.	3
10	Poca información del estado del personaje	El juego no representa de forma clara el estado del personaje	No se sabe exactamente cuanta "vida" me queda, por ejemplo, tenia mi pantalla "llena de sangre" me seguían llegando disparos pero no moría.	8
11	La barra espaciadora hace una acción extraña en un FPS	Usualmente la barra espaciadora se utiliza para saltar. En este juego se usa para "disparar una bala especial"	Cada vez que veía un obstáculo intentaba saltarlo apretando espacio.	6
12	Falta de Mapa o radar, provoca confusión al usar el "drón"	El juego no proporciona un mapa o un radar, por lo que se generan complicaciones al momento de usar el dron.	Al usar el dron, las paredes se hacen "translúcidas" y uno ve la silueta del enemigo, pero al no existir un mapa o un radar, y al "desaparecer parcialmente" las paredes, uno trata inconscientemente de atacar a través de una pared.	10
13	acciones del juego perjudican la inmersión	El mouse acciona la barra de tareas o la ventana del mismo juego, provocando que el mouse se trabe y no deje moverse	Al ejecutar las acciones de la escena de Quick time event,	4
14	incoherencia en la ubicación del objetivo	La flecha que debería indicar el lugar a donde ir está apuntando a la dirección contraria	Al seguir un objetivo	8
15	Acción de correr diferente con el área de aplicación	el personaje corre sin necesidad de las teclas de movimiento, provocando que solo corra hacia adelante	Al presionar a tecla de correr	1