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Player Experience Evaluation: a Brief Panorama of Instruments and Research Opportunities

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Abstract

The influences, metrics, and applications of User Experience (UX) have been investigated in various contexts and is acknowledged as a driving force to promote game development choices. Recently, there has been a growing interest and need to explore the experience in the context of digital games, which require particular forms of Player Experience (PX) components due to their interaction. These particularities of digital games bring some specific models, characteristics and evaluation methods based on this field. Therefore, both industry professionals and researchers must make informed choices when planning these assessments. This research aims to provide a brief panorama on how PX have been evaluated, and discuss its related concepts, based on the analysis 58 PX evaluation instruments. The data analysis provides a glance on the directions the research on PX evaluation is taking and indicates future research opportunities.

Keywords: *Player Experience, User Experience, Digital Games, Evaluation Approaches*

1 Introduction

The area of Human-Computer Interaction (HCI) has been broadly investigating User experience (UX) (Hassenzahl and Tractinsky, 2006; Nacke et al., 2019), as well as its applications, metrics, advancements, and influences in the interaction with many types of applications, including the increasing area of digital games (Nacke et al., 2019). The fact that successful games have the ability to engage users for hours and make them learn complex tasks has instigated the interest of the academic community around game features and game experience particularities (Malone, 1982; Carter et al., 2014; Bernhaupt et al., 2015).

Digital games and HCI have been linked since the first CHI conference in 1982, when Malone, based on his study on computer games, reinforced a set of design principles that could be applied for "enjoyable" user interfaces (Malone, 1982). Since then, researchers have seen that we (as HCI academics) could learn from games, but we could also support the game development industry - and that's where Game User Research (GUR) takes place. Seif El-Nasr et al. (2012) introduce GUR as "a field concerned with developing a set of techniques and tools to measure the users' behaviors and ultimately improve their experiences as they engage with games" (Seif El-Nasr et al., 2012).

Experience is one of the driving forces for game designers when making choices during the project and development of games. This evidence was first identified in the work of DeAnda and Kocurek (2016), after reviewing three books commonly used in game design courses: The Art of Game Design: A Book of Lenses (Schell, 2014); Challenges for Game Designers: Non-Digital Exercises for Video Game Designers (Brathwaite and Schreiber, 2008); and Game Design Workshop: A Playcentric Approach to Creating Innovative Games (Fullerton, 2014). To emphasize the importance of experience for game design, the authors state that designing a game is related to creating the best experience possible for the players. This process occurs by incorporating practices that go beyond programming to cover iterative design, game testing and attention to User Experience (DeAnda and Kocurek, 2016). Their viewpoint is in accordance with the earlier HCI perspective brought by Bernhaupt (2015), which sees the main goal of developing a game as creating a product that is fun to play, has surprises, provides challenges to players and promotes social connections. In HCI, the particular forms of interactivity of digital games is what divides them from other paradigms of interactive digital systems, such as desktop systems, that are developed to execute a specific group of tasks.

Thus, digital games demand particular ways of evaluating the experience of players (Sánchez et al., 2012), which motivated the development of several players' experience evaluation approaches that have been used during the game development and also after the game release (Bernhaupt, 2015). Over the years, several Player Experience (PX) evaluation instruments[1] and guidelines were either developed or adapted specifically for games (Sánchez et al., 2012). It means that PX evaluation towards gaming in Industry has been carried out since before GUR became an established research domain. However, these evaluations - and often, the employed instruments - are usually informally done, and do not follow proper guidelines (Wiemeyer et al., 2016).

Besides, as research in games interaction and development advanced, several different terms arose to somehow describe

[1] We understand "experience evaluation instruments" as any planned and validated tools (ranging from self reported scales to software) designed to systematically collect qualitative data and/or measure quantitative data related to experience constructs from a variety of participants, and to produce results based on psychometric properties, in a format ready for analysis (Darin et al. (2019))

the experience in games (e.g., Gaming Experience, Game Experience, Player Experience, User Experience). These terms are commonly used without a proper discussion of their definition and meaning, although they usually carry different perspectives and understandings (Sánchez et al., 2012). In this context, evaluating the experience of players in digital games is a rather complicated task, due to the inherent complexity of games in addition to the several different ways of addressing Player Experience, the wide variety of evaluation instruments, and the uncertainty about the assumptions on which they are built.

This scenario is even more difficult in countries where the Games Industry is mainly composed of independent game developers that generally work with a limited budget - commonly based in crowdfunding - and rely on small teams in which one person exercises different functions (e.g., Brazil) (Costanti, 2018). In these cases, it is uncommon to find a team with an HCI expert to consider the multiple human factors and experience components and then choose the most appropriate ways to evaluate a game under development. Consequently, at times, evaluations are planned and conducted based on the game developer's personal experiences and restricted knowledge about available methods and instruments, which compromises the quality of players' experience evaluation.

This paper aims to help to fill in the gap of lacking information about instruments to support the evaluation of Player Experience in digital games and their assumptions, considering the different components of the PX and types of available instruments. This work is an extension of a previously published paper (Borges et al., 2019) and aims to provide deeper analysis and discussions about what the PX evaluation instruments measure, their applications in different contexts and about the terms used to define the Player Experience. In this paper, despite the lack of consensus about the terms used to describe the experience in games, we adopt the term Player Experience to present our discussions and analysis.

The present study provides a brief panorama on how PX have been evaluated, and discuss its related concepts, based on the analysis 58 PX evaluation instruments. The data analysis provides a glance on the directions the research on PX evaluation is taking and indicates future research opportunities. Finally, we also discuss how the cataloged instruments address these different perspectives, as well as some trends and issues for the GUR field. We expect this paper to help game developers and designers, UX and PX researchers, and students of co-related areas to make informed choices when planning the evaluation of the Player Experience in digital games, as well as to outline future research in this field.

2 Experience in Games

To better understand the panorama of Player Experience perspectives in games evaluation, in this section, we discuss the different terms describing such views. Then, we discuss the differences between Playability and Player Experience. Lastly, we explore some of the fundamentals behind the Player Experience and its components and dimensions.

2.1 Multiple Terms and perspectives

Different perspectives affecting both game design and evaluation have been discussed in the literature for understanding UX in games. Distinct terms have been adopted to describe these viewpoints in the literature concerning UX evaluation in digital games, such as Game Experience (Poels et al., 2007a; Lai et al., 2012), Gaming experience (Calvillo-Gámez et al., 2015; Jennett et al., 2008), Player Experience (Lazzaro, 2008; Wiemeyer et al., 2016), and User Experience (Qin et al., 2009; Sweetser and Wyeth, 2005). However, these terms are frequently used without a clear distinction of their definitions and what they represent to the studies (Wiemeyer et al., 2016).

Poels et al. (2007a) described the term Game Experience as a multidimensional and multilayered concept that refers to the users' feelings and experiences when playing digital games. In their study, the authors explored this concept in focus groups. The results allowed the categorization of aspects that would constitute Game Experience: enjoyment, flow, imaginative immersion, sensory immersion, suspense, competence, negative affect, control, and social presence.

Calvillo-Gámez et al. (2015) refer to the term Gaming Experience when they presented the Core Elements of Gaming Experience (CEGE). CEGE is where a positive experience - or enjoyment - is achieved according to the elements defined as Video-game and Puppetry. For them, Video-game is related to the player's interaction, while Puppetry is related to the player's perception of the game.

As for Player Experience (PX), Wiemeyer et al. (2016) depicted PX as the quality of player-game interactions, and it is typically investigated during and after the interaction with games. In this definition, PX is also divided into three levels: the psychological (social) level, which refers to the individual experience, the behavioral level and the physiological level. This distinction allows the experience to be evaluated more precisely by integrating physiological methods (e.g., heart rate, electrodermal activity) and behavioral methods (e.g., eye-tracking) to supplement the commonly used psychological approaches (e.g., surveys and questionnaires) (Wiemeyer et al., 2016).

User Experience is a broader term that is also used to address games evaluation and has been widely investigated within the HCI field. According to the definition in ISO 9241-11, User Experience encompasses "user's perceptions and responses that result from the use or anticipated use of a system, product or service" (Iso, 2018). However, literature reviews and surveys indicate that there is no agreement about the scope and definition of UX in both Academy and Industry (Law et al., 2009; Melo and Darin, 2019). The same phenomenon is seen in the context of games (Bernhaupt, 2015).

Some authors view UX as a construct that should be an intrinsic part of the game development lifecycle, in which practitioners should use specific kinds of UX evaluation methods (Bernhaupt, 2015). In this perspective, Bernhaupt (2015) discusses that while user experience evaluation methods from HCI are used during game development, HCI as a field is borrowing and exploring aspects of the gaming experience like immersion, fun, and flow to better understand the concept of user experience.

Some researchers are focused on distinguishing the terms addressing UX in games. Isbister and Schaffer (2008) argues that UX and PX are different concepts: UX would be the experience of game use, while PX is related to which kind of enjoyment the player is seeking. In Isbister and Schaffer perspective, PX analyzes what keeps the player away from having fun, while UX observes what creates boundaries to the ability of gaming. On the other hand, Nacke and Drachen (2011) consider PX as UX in the specific context of digital games.

Literature has also compared Game Experience and Player Experience. Wiemeyer et al. (2016) argue that Game Experience had its place taken by PX in a similar way that usability had its place taken by UX - although this perspective is debatable. However, they consistently argue that the term Game Experience is closer to technology than to the subjective experience of humans (Isbister and Schaffer, 2008). Hence, for the authors, Player Experience is a more appropriate term than Game Experience, as the one having this specific experience is the player (Wiemeyer et al., 2016).

The choice of a term that best describes the experience in games is so far an open debate. Among the existing terms for describing experience in the context of digital games, in this study, we chose to address experience in games as Player Experience (PX) - following Wiemeyer et al. rationale.

2.2 Playability and Player Experience

Despite various perspectives to define the experience in digital games, there is a general agreement that usability is essential, but is not enough or determinant in game development (Nacke and Drachen, 2011), due to its standard metrics are not mapped directly to game evaluation (e.g., effectiveness measured as task completion or efficiency, error rates) (Wiemeyer et al., 2016). Game design requires a primary focus on human and subjective factors, such as the emotional and cultural aspects of the players (Sánchez et al., 2012; Wiemeyer et al., 2016).

To measure and evaluate usability within game development, researchers need to combine classical usability factors with the subjective aspects inherent in digital games (Sánchez et al., 2012). Thus, the concept of Playability was coined. According to Sánchez et al. (2012) this term measures and describes the quality of a game at a technological level (e.g., within the scope of rules, mechanics, design, and goals) and is affected by factors like graphics, sounds, storyline, and control.

It is common to confuse Playability with Player Experience, but the terms include aspects that are quite distinct when analyzed. In a nutshell, Playability seeks to guarantee a good experience at a technological level, whereas Player Experience is about the quality of player-game interactions during and after they occur (Wiemeyer et al., 2016). PX focuses on the player and is based on the measurement of three levels of experience: socio-psychological aspects, behavioral and physiological reactions (Wiemeyer et al., 2016). Hence, Playability is the basis for a good Player Experience (Sánchez et al., 2012; Wiemeyer et al., 2016).

2.3 Player Experience Components and Dimensions

According to Wiemeyer et al., one must consider a diversity of factors to comprehend what Player Experience is. Those PX factors are the elements that contribute to this type of experience and come from many disciplines (e.g., neurophysiology, psychology, and sociology). Although there is no consensus on what specific factors constitute PX (Nacke and Drachen, 2011), there is a shared comprehension that PX is a multidimensional and multilayered construct (Poels et al., 2007b). Thus, several psychophysiological models have been developed to explain PX's structure and the diverse components influencing this experience (Wiemeyer et al., 2016).

A variety of terms have been used to name what Wiemeyer et al. (2016) called factors, such as dimensions, constructs, and components. However, there is no clear distinction between these terms within the literature. For example, Poels et al. (2007a) and Poels et al. (2012) consider Flow and Immersion factors as dimensions, while Denisova et al. (2016) and Ermi and Mäyrä (2005) refer to them as components. There are also studies where the terms *dimensions* and *components* are used interchangeably, without definition of their correlation (Wiemeyer et al., 2016) (Drachen et al., 2010).

In this paper, we chose to use the terms *components* and *dimensions* to describe PX factors. We consider *components* as the factors that manifest different facets of the Player Experience (e.g., Flow, Immersion and Presence); and *dimensions* as the elements that scope components (e.g., engagement, engrossment and total immersion are dimensions of the PX component Immersion (Cheng et al., 2015)). A PX component may be described by different dimensions, depending on the author's theoretical assumptions. For example, Poels et al. (2007a) differs from Cheng et al. definition of immersion and considers that it is made up of sensory immersion and imaginative immersion.

Hence, in this paper, we consider PX as a construct that characterize the quality of the player-game interaction in terms of a set of components which may be defined by a subset of dimensions, encompassing socio-psychological aspects, and behavioral and physiological reaction.

The variety of understandings about the same components results in different approaches of PX evaluation. This phenomenon is clear when considering some of the most usual components of PX: Immersion (Jennett et al., 2008; Cheng et al., 2015), Enjoyment (Fitzgerald et al., 2020; Sweetser and Wyeth, 2005), and Presence Witmer et al. (2005); Schubert et al. (2001).

Immersion is usually addressed as the outcome of a good experience (Jennett et al., 2008), and it is used to measure the degree of involvement with a game. Jennett et al. (2008) developed a self-report questionnaire in which the dimensions of immersion are: cognitive involvement, real-world dissociation, emotional involvement, challenge and control. However the Game Immersion Questionnaire (GIQ) (Cheng et al., 2015), which evaluates the same PX component, describes it with different dimensions: engagement, engrossment, and total immersion.

Another example can be seen in Enjoyment, which can

be defined as the feeling of pleasure resultant from gaming (Fitzgerald et al., 2020), and is the most important goal in digital games as it determines whether the user is willing to play the game (Sweetser and Wyeth, 2005). On one hand, the Exergame Enjoyment Questionnaire (EEQ) (Fitzgerald et al., 2020), consider immersion (here understood as a dimension instead of a PX component), intrinsically rewarding activity, control, and exercise as dimensions of Enjoyment. On the other hand, the EGameFlow Scale (Fu et al., 2009) considers concentration, goal clarity, feedback, challenge, autonomy, immersion, social interaction, and knowledge improvement as Enjoyment dimensions.

We highlight that these PX components - as well as other PX components - may also have slightly different definitions and dimensions from one measurement instrument to another. Nevertheless, each different perspective brought by distinct evaluation perspectives contributes to analyzing PX in games and virtual environments more thoroughly.

3 Methodology

This work is an extension of a previous work describing the PX Instruments Catalog (Borges et al., 2019), in which we analyzed and cataloged 47 instruments for evaluating different components of experience in games and virtual environments, based on four attributes (type of instrument, target users, UX qualities evaluated and year of publication).

The present study aims to refine, expand, and deepen the analysis and discussions produced in the initial research. Hence, we searched more instruments in the literature, reviewed the instrument papers, gathered more information about each of them and analyzed the data of the final 58 instruments according to eight attributes (Table 1).

Our methodology followed four steps (Figure 1): 1) Literature search, 2) Refinement and expansion of PX instrument catalog, 3) Data extraction, 4) Data analysis and categorization of instruments.

First, we conducted a literature search to deepen the theoretical background on PX fundamentals. This step fomented a broader understanding of the different terms describing the experience in digital games, (including Game Experience, Player Experience and User Experience), the differences between playability and Player Experience, in addition to discussions about PX components and dimensions. This step was important to define the attributes that would later be used in data analysis (as described in Step 3).

In Step 2, aiming to refine the PX Instruments Catalog (Borges et al., 2019), two researchers reviewed the extracted data of the 47 previously cataloged instruments. Each researcher read the papers, double-checking and supplementing information on type of instrument, approach, PX components, and target users. Researchers also identified and removed two duplicated instruments, which were described in different papers. Then, to expand the PX Instruments Catalog, we identified 13 new PX instruments after running a forward snowballing (Wohlin, 2014) on the 45 papers on the PX Instruments Catalog, resulting on 58 papers.

In Step 3, a researcher read the full text and extracted data from the 58 papers. In addition to the original set of four attributes, he analyzed four additional attributes for each instrument, resulting in the final eight:

Figure 1. Summarized steps of the present study.

1. type of instrument (e.g., scales and questionnaires, softwares and equipments, two-dimensional diagram);
2. type of approach (e.g., qualitative, quantitative, quali-quantitative);
3. PX components;
4. dimensions describing the PX components;
5. target users;
6. instrument language;
7. perspective of experience (i.e. terms authors used to refer to experience in games);
8. type of collected data (i.e. the type of data the instruments collect to evaluate the experience).

After that, another researcher reviewed the data extracted for each paper.

In Step 4, two researchers analyzed the extracted data by tabulating and categorizing them according to eight attributes. After that, we used descriptive statistics to categorize and summarize the data of the entire set of instruments and within each type of instrument. Besides, we also searched for trends in the instrument's data over the years and analyzed how their authors described the experience in games, their evaluated PX components and dimensions, as well as the relationships between them. The Table 1 shows the different attributes of the analysis in the previous paper (Borges et al., 2019) and the present study.

The analysis of trends in the instruments data brought

Table 1. Collected and analyzed data in the previous and present study

	Previous study	**Present study**
Number of instruments	47 instruments	58 instruments
Analyzed attributes	Year Type of instrument Target users UX qualities	Year Type of instrument Target users Language Type of collected data Components Dimensions Perspective of Experience

novel insights and perspectives about the definition of Player Experience, its facets, the understanding of its components and dimensions, the divergences about how to evaluate the PX components and about how cultural aspects are considered in PX evaluation. These topics are further discussed in Sections 4 and 5. Additionally, an updated version of the PX Instruments Catalog can be accessed in this address [2].

4 Results

The Player Experience Instruments Catalog resultant from this research comprises 58 instruments that evaluate different perspectives of experience in games and virtual environments (Table 11 and Table 12, in the Appendix). In this section, we present the data of the instruments according to their types and attributes.

4.1 Overview

The 58 cataloged instruments evaluate 70 different components of PX, which are showed in the Figure 2 (the size of the words is proportional to the number of instruments that evaluate the respective component). The components most evaluated by the instruments were immersion (evaluated by 11 instruments), presence (nine instruments) and challenge (seven instruments). We categorized the components evaluated by two (3.45%) instruments as "Others", because their articles showed that the instruments also evaluated other aspects or constructs in addition to the Player Experience (Savi et al., 2011; Petri et al., 2016). The papers of the instruments presented a large amount of terms to define the PX components and these terms diverge for each author. Therefore, it is important to highlight that this study's goal is not to analyze the theoretical reasoning behind them.

We classified the 58 instruments into three different types: scales and questionnaires (82.76%), software and equipment (15.52%), and diagrams and two-dimensional graph areas (1.72%). Table 2 exemplifies the instruments of each of those types and the components evaluated by them.

As for target users, we identified three categories: children, learners and "players in general". The last one classifies instruments that do not determine a specific target user or are intended to all types of players. Only two (3.45%) out of 58 cataloged instruments are specifically targeted to children (Vissers et al., 2013; Moser et al., 2012) and also one (1.72%) is directed to learners (Fu et al., 2009), while 55 (94.83%) did not define a particular type of target player and/or were intended to all types of players.

Table 2. Different types of instrument and the components they evaluate.

Type of instrument	Components	Ex. (Paper ID)
Scales and Questionnaires	Immersion	P14
	Presence	P36
	Challenge	P55
	Flow	P30
	Enjoyment	P7
Software and Equipment	Behavior	P8
	Emotion	P9
	Aesthetic Experience	P2
Two-dimensional diagrams and graph area	Usability	P24
	Challenge	P24

Regarding the different perspectives to understand experience in games, the 58 cataloged instruments presented seven different perspectives. Twelve (20.69%) of them use the term "Game Experience" (e.g.Moser et al. (2012)); 11 (18.97%) use "Player Experience" (e.g.Granato et al. (2018)); seven use "User Experience" (e.g.Lin et al. (2002)); five (8.62%) instruments use "Gaming Experience" (e.g.Calvillo-Gámez et al. (2015)); just one (1.72%) use "User's Gameful Experience" (Högberg et al., 2019); one (1.72%) use "Game-playing Experience" (Brockmyer et al., 2009) and also one (1.72%) use "Playful Experience" (Boberg et al., 2015). Twenty instruments (34.48%) do not report under which perspective of the experience they were developed (e.g.Ravaja et al. (2004)), so that they do not use any specific term to describe experience in games.

The instruments that use the term "Player Experience" evaluate 31 different components. In comparison, those who use the term "Game Experience" evaluate 26 different components, and the instruments developed with the perspective of "User Experience" evaluate 12 different components. Table 3 shows all the perspectives of experience found, the number of instruments that use each one, and how many components are evaluated by the instruments of each perspective.

The cataloged instruments were developed in different languages, so that 50 (86.21%) out of the 58 are in English only (e.g.Ravaja et al. (2004)), while five (8.62%) have an English version and a translated version (Dutch and Portuguese) (e.g.Petri et al. (2016)) and three (5.17%) instruments are in Portuguese only (e.g.Vasconcelos-Raposo et al. (2016)). Table 4 shows the number of instruments which are not only in English and their references.

4.1.1 Instruments and components over the years

Over the years, we can observe the constancy with which new instruments are developed and also the prevalence of scales and questionnaires over other types of instrument. Since 1998 (when the oldest cataloged instrument was published (Witmer and Singer, 1998)), at least one instrument for evaluation of experience in games was developed per year - except for the year 2000. Scales and questionnaires are the most recurrent type of instruments, so that every year since 1998,

[2] `celulamultimidia.ufc.br/catalogo-ux-jogos/` Access date: 12/08/2020

Figure 2. All the components of experience evaluated by the instruments

Table 3. Different perspectives of experience in games.

Perspective	no. Instruments	no. evaluated components
Game Experience	12	26
Player Experience	11	31
User Experience	7	12
Gaming Experience	5	11
User's gameful experience	1	1
Game-playing experience	1	1
Playful experience	1	1
Not specified	20	21

Table 4. Instruments which are not only in English.

Language	no. instruments	Paper ID
English and translated version	5	P41, P48
Portuguese only	3	P22, P47, P50

at least one instrument of this type was identified, except for the years 2000 and 2010 (Figure 3).

Unlike scales and questionnaires, the publication of softwares/equipments and two-dimensional diagrams only occurs years laters, from 2008 and 2013, respectively, and less frequently. Between 2008 and 2020, the softwares and equipments rate per year is 0.69. From 2013 to 2020, the average of two-dimensional diagrams is 0.13 per year. Meanwhile, the average of scales and questionnaires per year, from 1998 to 2020, is 2.09.

Although we observed a predominance of scales and questionnaires, the instruments of other types have been developed more frequently throughout the years. We identified 24 scales and questionnaires and only two instruments of other types developed from 1998 to 2009. Meanwhile, from 2010 to 2020, also 24 scales and questionnaires were developed, but we identified eight of other types (four times more than in the first period), which represents an increasing trend in the frequency of other types of instruments to evaluate the experience in digital games (Figure 4).

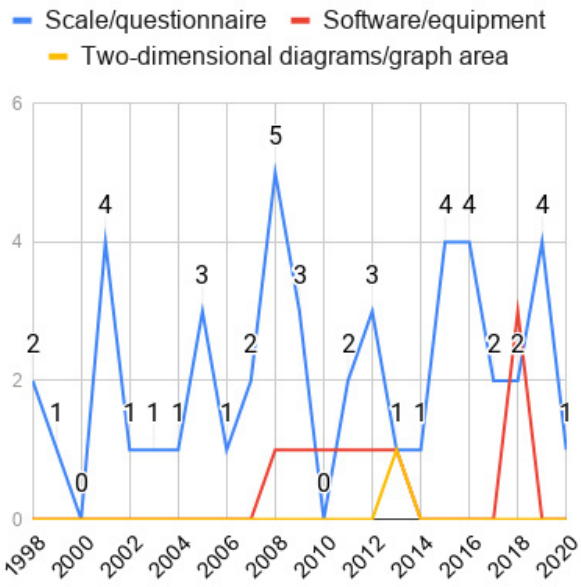

Figure 3. Instruments per year.

Regarding the components of the Player Experience, from 1998 to 2020, we noticed a significant increase in the number of evaluated PX components by the instruments throughout the years. Figure 5 shows the number of PX components measured by the instruments of each year. From 1998 to 2009, the instruments evaluated 26 different PX components, while be-

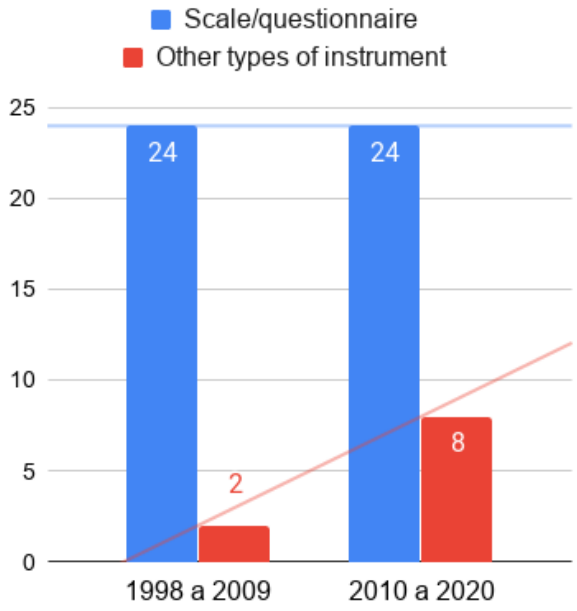

Figure 4. Questionnaires and scales per decade.

tween 2010 and 2020, 58 components of the experience were evaluated.

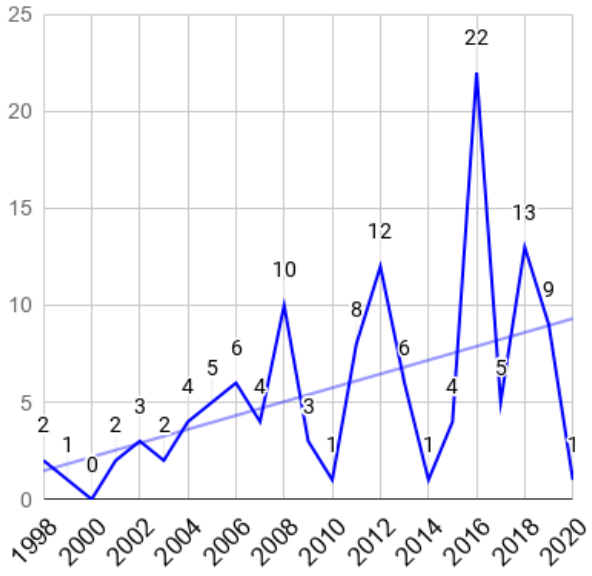

Figure 5. Number of components that the instruments of each year aim to evaluate.

4.2 Types of Instruments

The different types of cataloged instruments present particular trends in their data. The data analysis showed different concentrations of PX components, dimensions and target users between the scales and questionnaires and the other types of instruments.

4.2.1 Scales and Questionnaires

Among all types of cataloged instruments, verbal and nonverbal scales and questionnaires prevail with 48 (82.76%) instruments, appearing significantly more than other types. Scales and questionnaires, despite their conceptual differences, are reported as a single category ("scale/questionnaire") because both terms are frequently used in an exchangeable way, alongside the cases in which scales are developed only for a specific questionnaire (e.g. Poels et al. (2007b)).

Among the 70 PX components found, 63 are evaluated by scales and questionnaires. The most recurring component in this type of instrument is Immersion (22.92%), followed by Presence (18.75%), Challenge (12.50%), Flow (12.50%), and Enjoyment (12.50%), as shown in Table 5.

The components evaluated by scales and questionnaires are often constituted by different dimensions, according to their authors. Table 6 shows the dimensions considered in the most recurrent components evaluated by this type of instrument.

Regarding the target users of the scales and questionnaires, from the 48 cataloged scales and questionnaires, 46 (95.75%) are intended for all types of players, while only one (2.08%) was developed specifically for children (Moser et al., 2012) and also one (2.08%) focuses on learners (Fu et al., 2009).

4.2.2 Software, equipment, and two-dimensional diagrams

Among the 58 cataloged instruments, nine (15.52%) are softwares or equipments, representing the second most recurring type of instruments found. These nine instruments evaluate three different components (Table 7): Behavior (55.56%), followed by Emotion (33.33%), and Aesthetic experience (11.11%). All the instruments of this type evaluate the experience with all types of players.

The other type of instrument we identified is two-dimensional diagrams and graph areas, with only one instrument, representing 1.72% of the total. The single instrument of this type intends to evaluate four different components (Table 8), which are usability, challenge, the quantity of play, and general impression (Vissers et al., 2013) and targets all types of players.

4.3 Components and dimensions

The cataloged instruments aim to evaluate different components of the experience. In most instruments, these components are fragmented in different dimensions that constitute them (Figure 6). We found 93 different dimensions of the components of the experience. Eleven (11.83%) of these 93 dimensions are shared by more than one component (e.g. control is a dimension that describes the component Immersion and also the component Flow (Qin et al., 2009; Sweetser and Wyeth, 2005). Table 9 shows: (i) these eleven dimensions; (ii) the components which they constitute; (iii) and the percentage of instruments which evaluate that component and consider the respective dimension.

Among the 93 dimensions found, only 18 (19.35%) appear in more than one instrument (e.g.control (Lin et al., 2002))

Table 5. Most recurring components evaluated by scales and questionnaires.

Components	Number of instruments	Paper ID
Immersion	11	P6, P41, P17, P18, P35, P36, P47, P49, P51, P56
Presence	9	P22, P23, P26, P42, P46, P31, P33, P37, P38
Challenge	6	P14, P17, P4,7 P48, P55
Flow	6	P15, P17, P30, P53, P54
Enjoyment	6	P6, P7, P11, P20, P21, P58

Table 6. Dimensions considered in the most recurring components evaluated by scales and questionnaires.

Component	Dimensions	Paper ID
Immersion	Curiosity, Concentration, challenge /skills, control, comprehension, empathy and familiarity	P56
	Cognitive involvement, real world dissociation, emotional involvement, challenge and control	P51
	Sensory immersion and imaginative immersion	P13
	Engagement, engrossment and total immersion	P18
Presence	Involvement, spatial presence and realness	P26
	Involvement, Sensory Fidelity, Adaptation/Immersion, Interface Quality	P38
	Behavior and locomotion	P31
	Spatial presence, engagement and ecological validity.	P22
	Involvement, spatial presence and realness	P42
	Sense of physical space, engagement, ecological validity and negative effects	P23
Flow	Concentration, challenge, skills, control, clear goals, feedback, immersion and social interaction	P54
	Challenge skills balance, action-awareness merging, clear goals, unambiguous feedback, concentration on the task at hand, sense of control, loss of self-consciousness, transformation of time and autotelic experience	P53
Enjoyment	Concentration, clear goals, feedback, challenge, autonomy, immersion, social interaction, knowledge improvement.	P7
	Immersion, intrinsically rewarding activity, control and exercise.	P58

Table 7. Components evaluated by software and equipment.

Components	Number of instruments	Paper ID
Behavior	5	P28, P34, P8
Emotion	3	P9, P10, P1
Aesthetic experience	1	P2

Table 8. Components evaluated by two-dimensional diagrams.

Components	Number of instruments	Paper ID
Usability	1	P24
Challenge	1	P24
Quantity of play	1	P24
General impression	1	P24

and 75 (80.65%) appear only once (e.g.tiredness (IJsselsteijn et al., 2008)). The dimensions that appear more often in the instruments, constituting different PX components are challenge, control, and immersion. Challenge appears as a dimension that constitute four different PX components: Immersion (Jennett et al., 2008), Flow (Lai et al., 2012), Enjoyment (Fu et al., 2009), and Gameful Experience (Högberg et al., 2019); Control is seen as part of four different PX components: Enjoyment (Fitzgerald et al., 2020), Immersion (Qin et al., 2009), Playfulness (Boberg et al., 2015), and Flow (Lai et al., 2012); Immersion - which is itself addressed as a PX component - is also used by some authors as a dimension that constitute other four PX components: Enjoyment (Fitzgerald et al., 2020), Engagement (Brockmyer et al., 2009), Gameful Experience (Högberg et al., 2019), and Flow (Sweetser and Wyeth, 2005). Table 10 shows examples of PX components and different dimensions found in the instruments that evaluate them.

4.4 Online Catalog of instruments

We organized and summarized the set of 58 instruments and its data in a virtual catalog, which is an updated version of the catalog presented by Borges et al. (2019). In its previous version, the catalog of PX instruments was integrated with the catalog of general UX instruments (Figure 7, in the Appendix). All instruments were sorted by the type of application (e.g. Games and virtual environments, Hardware and robotics) and were displayed as a linear list without additional filters (Figure 8, in the Appendix). The navigation was problematic, especially for users who did not know which type of instruments they were looking for. When that was the case, the user would have to go through all the list in order to consult each instrument - turning into a long and exhausting process.

In order to optimize the searching process, the PX evaluation instruments were separated from the others. Also, three additional filters were added: type of instrument, target-user, and PX components evaluated (Figure 9, in the Appendix). The new version can be accessed in the link available in this paper [3].

The catalog structure was planned to help researchers and

[3] `celulamultimidia.ufc.br/catalogo-ux-jogos/` Access date: 12/08/2020

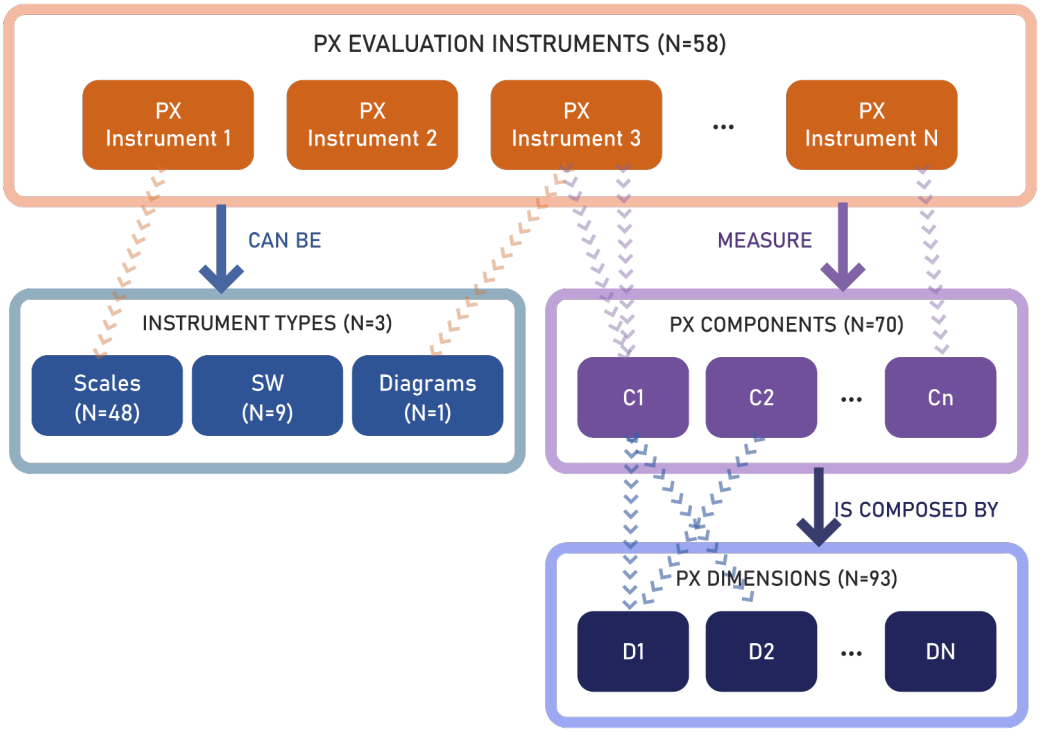

Figure 6. Relation between instruments, components, and dimensions, and the number of identified elements of each kind.

Table 9. Dimensions shared by different components.

Type of instrument	Components
Challenge	Enjoyment (16.67%) Gameful Experience (100%) Immersion (9.09%) Flow (16.67%)
Control	Immersion (18.18%) Flow (16.67%) Playfulness (100%) Enjoyment (16.67%)
Immersion	Enjoyment (33.33%) Engagement (25.00%) Gameful Experience (100%) Flow (16.67%)
Concentration	Enjoyment (16.67%) Flow (16.67%) Immersion (9.09%)
Engagement	Immersion (9.09%) Presence (22.22%)
Psychological involvement	Involvement (50.00%) Social presence (100%)
Behavioural engagement	Engagement (25.00%) Social presence (50.00%)
Behavioural involvement	Involvement (50.00%) Social presence (50.00%)
Competition	Gameful Experience (100%) Playfulness (100%)
Feedback	Enjoyment (16.67%) Flow (16.67%)
Social interaction	Enjoyment (16.67%) Flow (16.67%)

practitioners choose what instrument they should use to evaluate different components and dimensions of experience in games, based on their research goals.

Each instrument in the catalog presents the following information (as represented in Figure 10, in the Appendix): PX components, dimensions, type of instrument, type of approach, target-users, reference and name, in addition to the instruments general procedure and the main idea.

Table 10. Most recurring components and their dimension.

Component	Dimensions	Paper ID
Immersion	Engagement, engrossment and total immersion	P18
	Cognitive involvement, real world dissociation, emotional involvement, challenge and control	P51
Presence	Sense of physical space, engagement, ecological validity and negative effects	P23
	Involvement, Sensory Fidelity, Adaptation/Immersion, Interface Quality	P38
Emotion	Valence and arousal	P9
Involvement	Psychological involvement and behavioural involvement	P16
Momentary mood	Joy, pleasant relaxation, fear, anger, depressed feeling.	P26

The main idea and the general procedure present, respectively, a brief description of what the instrument is, and how it should be administered in evaluation, or how it was applied in the study in which it was presented. Regarding the types of instruments, they were divided into three categories: ques-

tionnaires/scales, software/equipment, and two-dimensional diagrams/area graphs. The type of approach of the instruments can be quantitative, qualitative, or quali-quantitative. The instruments' target-users were classified into children, learners, and the category of players in general, which consists of instruments that did not have a specific public and/or can be used with every type of user.

We implemented all these data types as filters to enable finding instruments according to their goals, the types of instruments they intend to use, and the targeted-users' profile. The full version of the catalog is available in Portuguese [4].

5 Issues and Research Opportunities

Based on the data gathered from the instruments, its analysis and on the theoretical background about evaluation of the experience in digital games, we highlighted and discussed about some questions in this context, which we present in this section.

5.1 Why so many scales?

According to the data collected and analyzed in this research, scales and questionnaires are the most recurrent types of cataloged instruments. This type of evaluation instrument can either be robust (with results with a high level of validity) and have superficial quality, generating questionable data regarding its validation (Lazar et al., 2017). Thus, the evaluation results would depend on the quality of the questionnaire, its construction and validation and the team's understanding of how to use it.

The usage of these instruments is broadly disseminated since the initial development stages of HCI science (Ozok, 2009), due to their accessibility and cost, as they do not need special technological equipment to be used. The results provide access to individual user information based on personal factors such as satisfaction, opinions, and ideas concerning the experience around some system usage (Ozok, 2009) - these being some basic concerns in studies of UX.

According to Carneiro et al. (2019), besides the application of this instrument type being rather convenient, there is also a frequent adaptation of questionnaires in the context of evaluating games. However, these adaptations usually don't follow any guidelines nor guarantee the psychometric properties of the original instruments (Carneiro et al., 2019). According to the authors, the substantial variety of constructs or components within the Player Experience can aggravate the issues arising from these adaptations.

The scales and questionnaires cataloged in this study are aimed to evaluate 63 different components of Player Experience and other perspectives of experience in games. The ease of creation (when informally done), adaptation, and use of this type of instrument may be one of the causes of this variety of components, which is further complicated by the lack of consensus on the constructs that constitute the PX and the different perspectives considered by authors.

Hence, if both Academy and Industry take more responsibility towards creating and adapting these instruments, the psychometric measures are less jeopardized in the process. It is important to follow strict methodologies to create, adapt and validate the instruments.

General UX evaluation scales should be avoided in games because games and virtual environments have crucial particularities when compared to other systems. Games require a considerable mental activity rate (i.e. cognition, emotion, and motivation (Komulainen et al., 2008)), stimulated by recurring elements in the game context among (Takatalo et al., 2010). Attributes such as surprise, stress, and fear levels, may be desirable, which usually is not the case in other systems. Besides, attributes like these are probably not satisfyingly explored by scales and questionnaires only, requiring combination with other types of instruments, such as post-test images (Desmet, 2003) and specialized software (Ayzenberg et al., 2012).

Despite the prevalence of scales and questionnaires, these other types of instruments have been developed more constantly throughout the years, so that this prevalence tends to decay. Whilst more types of instruments are developed, the amount of PX components evaluated increases, which may be due to the evolution of the technology applied in these instruments' development and how they can assess more types of data than scales and questionnaires. The evolution of the games throughout the years can be another reason for this increase, as well as the growth of the discussions in the literature about the experience in games and what composes it.

5.2 What am I evaluating when I evaluate PX?

The academic divergence regarding a concept that addresses experience in games and what it comprises is obvious. It is reflected in the variety of terms used to study it - Player Experience, Gaming Experience, Game Experience, and User Experience. The literature states that UX in the game context, supported by digital technology, is responsible for provide the Player Experience and its multiple potentialities (Nacke and Drachen, 2011; Bernhaupt, 2015).

The instruments cataloged in this study presented seven different terms to refer to the experience in games (Player Experience Game Experience, Gaming Experience, User Experience, User's Gameful Experience, Game-playing Experience, and Gameful Experience), so that the most recurrent terms were Player Experience and Game Experience. Several papers introduced instruments that did not make it clear to which type of experience they referred. Often, components are described by very different sets of dimensions with no reasoning about the theoretical frameworks and experience perspectives being considered.

Although many authors have been working on formalizing the terms and the scope of Player Experience (Bernhaupt, 2015; Isbister and Schaffer, 2008; Nacke and Drachen, 2011), this may still be one of the causes of the wide variety of components of the experience identified. Among the 70 different PX components found, only 22 appear more than once in the instruments. This variety is even more evident in scales and

[4] `celulamultimidia.ufc.br/catalogo-ux-jogos/` Access date: 12/08/2020

questionnaires, which evaluate 63 of these PX components through 48 instruments.

These results in several different assumptions behind the measurement of a PX component and reinforce major conceptual divergences about experience in games. For example, the instrument MEEGA+ considers that Player Experience can be evaluated by measuring Focused attention, Fun, Challenge, Social interaction, Trust, Relevance, Satisfaction, Perceived Learning, and User error protection (Petri et al., 2016). However, the Player Experience Inventory (Abeele et al., 2020) measures PX with a completely different set of components: Immersion, Meaning, Mastery, Curiosity, and Autonomy. Yet the instrument Video Game Uses and Gratifications Instrument (Sherry et al., 2006) proposed that Player Experience can be measured by Competition, Challenge, Social Interaction, Diversion, Fantasy, and Arousal. Because of this lack of consensus concerning the definition and scope of Player Experience, it can be hard to know what is being assessed when an instrument claims to evaluate PX - and most of its components.

This fact indicates substantial differences between the psychometric properties of a construct and raises questions about how trustworthy are the different instruments.

It is important to both practitioners and researchers be careful to always select valid and widely tested instruments to evaluate experience in games. As researchers, we must be even more careful when creating and adapting PX instruments and consider whether it is really necessary to create new measurement scales for widely addressed PX components such as Immersion. Wouldn't instruments for evaluating experience in games be more robust if we focused our efforts on validating, translating, expanding, and improving already existing scales?

By creating more and more scales instead of improving, refining and translating of the existing ones, we may compromise the scientific progress of the field, as well as the usage of validated scales by the industry (Darin et al., 2019).

5.3 How are cultural aspects being considered?

Once the culture is one of the main aspects of user context and deeply influences human-computer interaction (Walsh et al., 2010), it is necessary to pay attention to one of its fundamental components: the language. Among the 58 cataloged instruments, only eight were developed in a language other than English (Portuguese and Dutch) (e.g. Savi et al. (2011), IJsselsteijn et al. (2008)) or had a valid translated version. Meanwhile, one instrument (Vissers et al., 2013) is nonverbal and is not confined to a specific language or requires translation. This large predominance of English instruments can be seen as an obstacle to the understanding of evaluated PX components and dimensions by untranslated instruments since language is a cultural expression, and it is essential to assimilate and diffuse the promoting experience (Coelho and de Mesquita, 2013).

The discussion brought by Walsh et al. (2013) about the consequences of UX evaluations with people whose mother tongue did not correspond to the instrument language also applies to the context of experience in games. A significant increase in a player's cognitive effort is necessary to answer an untranslated questionnaire - identified as the most used type of instrument in this study. The recurrence of this effort can be deduced to other evaluation technologies in which the user needs to translate (Walsh et al., 2013). When instruments are only available in English, they are only useful for people fluent in English. Even in this case, cultural differences between them and native English speakers can affect the validity of standardized questionnaires (Van de Vijver and Leung, 2001; Finstad, 2006).

However, just freely translating the instruments to players' language is also not a good alternative because the original psychometric properties of the instruments are not guaranteed, resulting in an invalid evaluation and making the data analysis untrustworthy (Walsh et al., 2013; Van de Vijver and Leung, 2001; Finstad, 2006). Hence, the wide range of PX components evaluated by the fifty scales and questionnaires in English may not be totally reliable if used with users who have a mother language other than English.

In addition to that, the difficulty of evaluating Player Experience in different users' contexts may be one of the causes that we have identified only two instruments that are intended for children (Moser et al., 2012; Vissers et al., 2013) in the present study. Although Padilla-Zea et al. (2013) consider that questionnaires enable access to qualitative data such as the users' satisfaction aspects and emotional impact in a posterior discussion with each participant, it is hard to analyze the collected data when it comes to children. This difficult occurs because children may not be reliable when answering questions (Padilla-Zea et al., 2013). When applying an evaluation instrument, the children's behavioral aspects must be considered. As Barendregt (2006) states, they have a more reactive and impulsive approach than a logical one, so they usually have problems at verbalizing their thoughts while interacting with digital technology (Barendregt, 2006).

There is room for both HCI and Games communities to develop Player Experience evaluation instruments that consider the particularities that portray children - and other players whose behavior is of interest - as well as to validate translations of valid English instruments.

6 Conclusion

This study presents an analysis of the data gathered from a set of 58 instruments to evaluate the experience in digital games, in addition to discussing about some questions regarding the terms used do describe the Player Experience, its components and dimensions, about the application of the instruments in an evaluation process and the impact of cultural and contextual aspects on the evaluation. We also developed an extended version of the catalog of Player Experience evaluation instruments developed by Borges et al. (2019), improving its navigation, adding 13 new instruments and displaying more detailed information about each instrument.

The analysis of the instruments data raised discussions that can be relevant for Game User Research and Player Experience future studies and related studies in User Experience and its concepts, evaluations, market, and academic trends. We expect that the discussed ideas presented in this article

may support and enhance other discussions about the scope and definition of Player Experience and its components or involved or co-related areas. The results of this research can be useful for some discussions about the translation and adaptation of instruments to other sociocultural contexts or specific publics, the development and adaptation of scales and questionnaires for different research goals, and also about the validation of instruments.

This study aims to support researchers and professionals in making informed decisions when choosing PX evaluation instruments in games and virtual environments with the discussions, data analysis, and the catalog of instruments presented here. For our future work, we plan to expand the catalog, including new instruments, extract and analyze additional data of the instruments, outline correlations between the terms used to describe Player Experience and its components and also draw comparisons between instruments for different applications.

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7 APPENDIX

Figure 7. Types of applications of the instruments in the catalog old version.

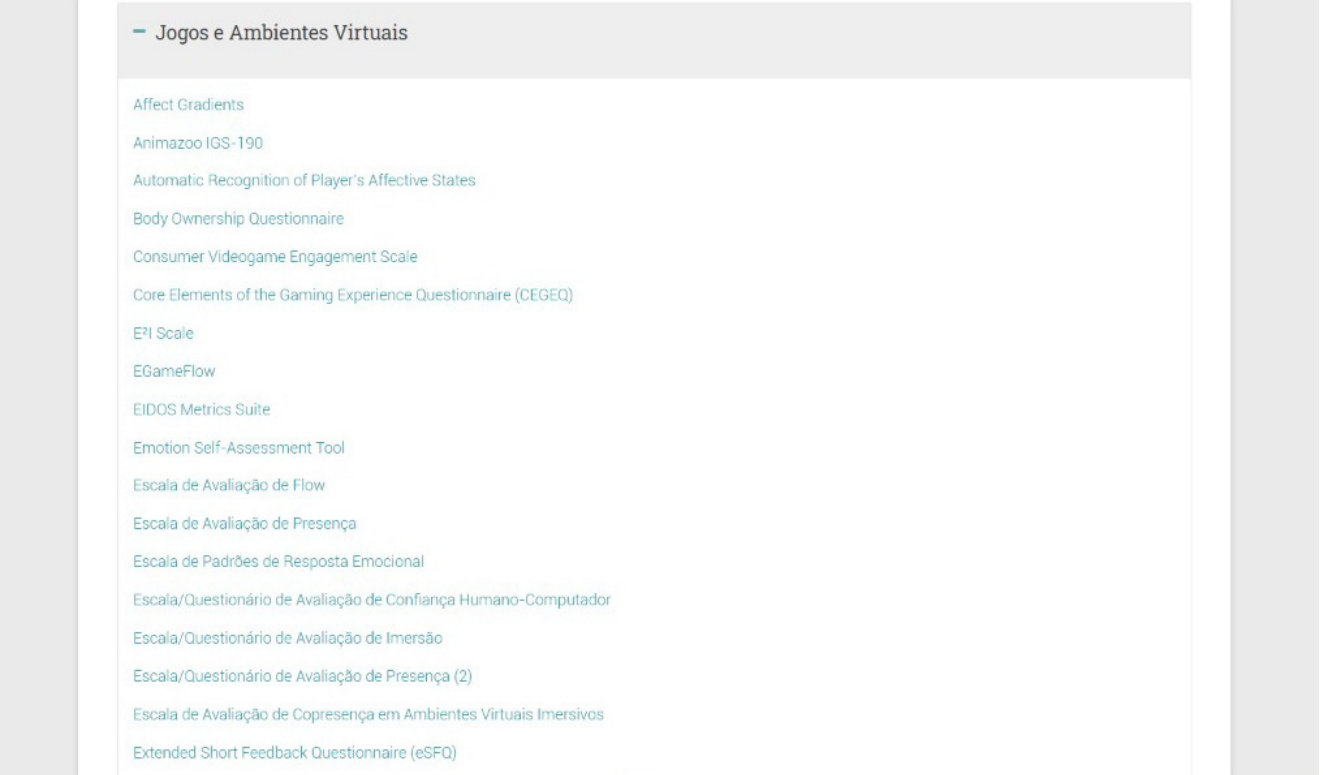

Figure 8. List of instruments in the catalog old version.

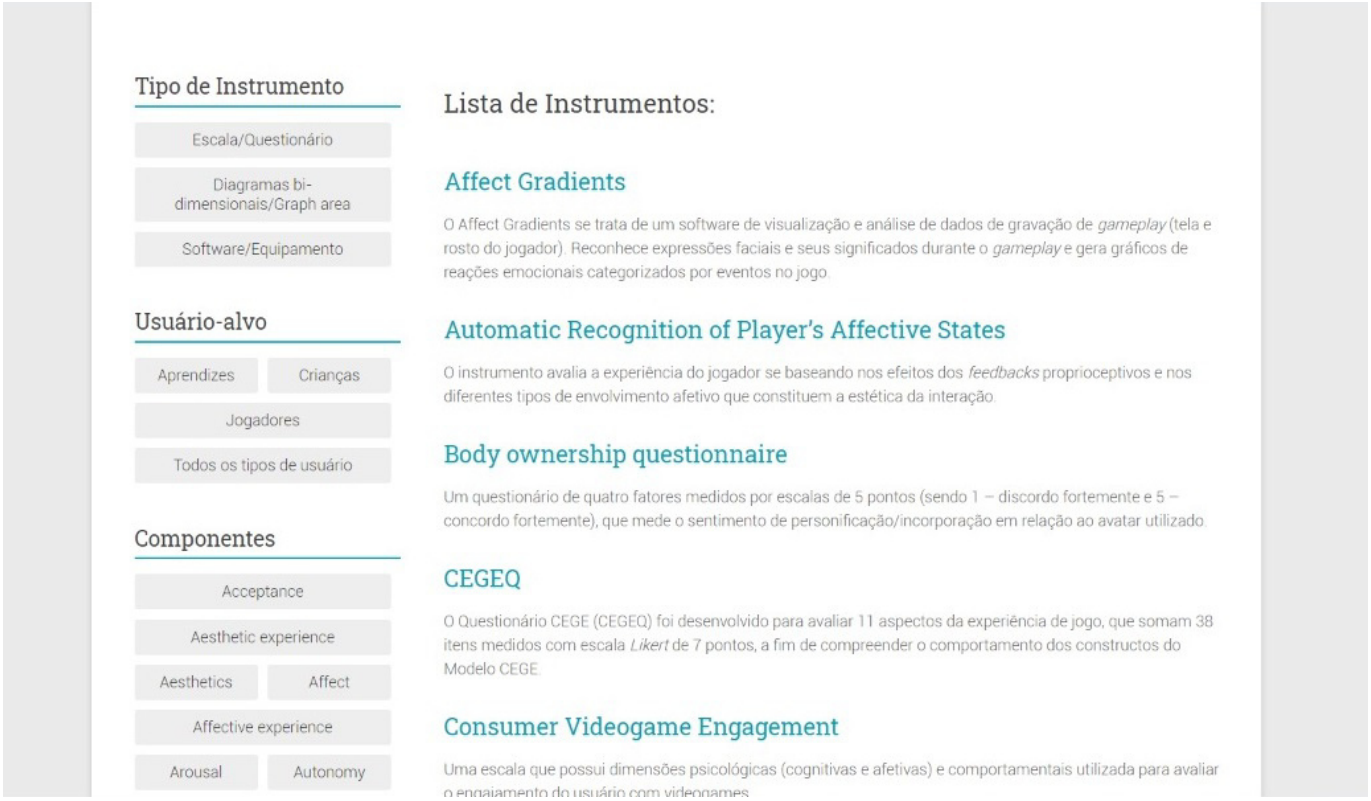

Figure 9. Filters in the new version of the catalog.

Figure 10. Information about the instruments in the new version of the catalog.

Table 11. Instruments name, paper ID and paper reference.

Paper ID	Name of instrument	Paper Reference
P1	Affect Gradients	Roohi, S., Takatalo, J., Kivikangas, J. M., Hämäläinen, P. (2018, October). Neural Network Based Facial Expression Analysis of GameEvents: A Cautionary Tale. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play (pp. 429-437). ACM.
P2	Automatic Recognition of Player's Affective States	Savva, N., Scarinzi, A., Bianchi-Berthouze, N. (2012). Continuous recognition of player's affective body expression as dynamic quality of aesthetic experience. IEEE Transactions on Computational Intelligence and AI in games, 4(3), 199-212.
P3	Body ownership questionnaire	Reinhard, R., Shah, K. G., Faust-Christmann, C. A., Lachmann, T. (2019). Acting your avatar's age: effects of virtual reality avatar embodiment on real life walking speed. Media Psychology, 1-23.
P4	CEGEQ	Calvillo-Gámez, E. H., Cairns, P., Cox, A. L. (2015). Assessing the core elements of the gaming experience. In Game user experience evaluation (pp. 37-62). Springer, Cham.
P5	Consumer Videogame Engagement	Abbasi, A. Z., Ting, D. H., Hlavacs, H. (2017). Engagement in games: Developing an instrument to measure consumer videogame engagement and its validation. International Journal of Computer Games Technology, 2017.
P6	E^2I scale	Lin, J. W., Duh, H. B. L., Parker, D. E., Abi-Rached, H., Furness, T. A. (2002, March). Effects of field of view on presence, enjoyment, memory, and simulator sickness in a virtual environment. In Proceedings ieee virtual reality 2002 (pp. 164-171). IEEE.
P7	Egameflow	Fu, F.-L., Su, R.-C. Yu, S.-C., 2009. EGameFlow: A scale to measure learners' enjoyment of e-learning games. Computers and Education, Issue 52, pp. 101-112.
P8	EIDOS Metrics Suite	Drachen, A., Canossa, A. (2009). Analyzing spatial user behavior in computer games using geographic information systems. Proceedings of the 13th International MindTrek Conference: Everyday Life in the Ubiquitous Era on - MindTrek '09.
P9	ESAT	Granato, M., Gadia, D., Maggiorini, D., Ripamonti, L. A. (2018, November). Software and hardware setup for emotion recognition during video game fruition. In Proceedings of the 4th EAI International Conference on Smart Objects and Technologies for Social Good (pp.19-24).
P10	DAPIS	Granato, M., Gadia, D., Maggiorini, D., Ripamonti, L. A. (2018, November). Software and hardware setup for emotion recognition during video game fruition. In Proceedings of the 4th EAI International Conference on Smart Objects and Technologies for Social Good (pp.19-24).
P11	Extended Short Feedback Questionnaire (eSFQ)	Moser, C., Fuchsberger, V., Tscheligi, M. (2012, September). Rapid assessment of game experiences in public settings. In Proceedings of the 4th International Conference on Fun and Games (pp. 73-82). ACM.
P12	Game Engagement Questionnaire	Brockmyer, J. H., Fox, C. M., Curtiss, K. A., McBroom, E., Burkhart, K. M., Pidruzny, J. N. (2009). The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing. Journal of Experimental Social Psychology, 45(4), 624-634.
P13	Game experience questionnaire (GEQ) - inGame Questionnaire	IJsselsteijn, W., Poels, K., De Kort, Y. A. (2008). The Game Experience Questionnaire: Development of a self-report measure to assess player experiences of digital games. TU Eindhoven, Eindhoven, The Netherlands, 42.
P14	Game experience questionnaire (GEQ) - The core questionnaire	IJsselsteijn, W., Poels, K., De Kort, Y. A. (2008). The Game Experience Questionnaire: Development of a self-report measure to assess player experiences of digital games. TU Eindhoven, Eindhoven, The Netherlands, 42.
P15	Game experience questionnaire (GEQ) - The post-game questionnaire	IJsselsteijn, W., Poels, K., De Kort, Y. A. (2008). The Game Experience Questionnaire: Development of a self-report measure to assess player experiences of digital games. TU Eindhoven, Eindhoven, The Netherlands, 42.
P16	Game experience questionnaire (GEQ) - The social presence module	IJsselsteijn, W., Poels, K., De Kort, Y. A. (2008). The Game Experience Questionnaire: Development of a self-report measure to assess player experiences of digital games. TU Eindhoven, Eindhoven, The Netherlands, 42.
P17	Game Experience Questionnaire (GEQ) [modified]	Christensen, J. V., Mathiesen, M., Poulsen, J. H., Ustrup, E. E., Kraus, M. (2018, April). Player Experience in a VR and Non-VR Multiplayer Game. In Proceedings of the Virtual Reality International Conference-Laval Virtual (p. 10). ACM.
P18	Game Immersion Questionnaire (GIQ)	Cheng, M. T., She, H. C., Annetta, L. A. (2015). Game immersion experience: its hierarchical structure and impact on game□based science learning. Journal of Computer Assisted Learning, 31(3), 232-253.
P19	GAMEFULQUEST - Gameful Experience Questionnaire	Högberg, J., Hamari, J., Wästlund, E. (2019). Gameful Experience Questionnaire (GAMEFULQUEST): an instrument for measuring the perceived gamefulness of system use. User Modeling and User-Adapted Interaction, 1-42.
P20	Gaming Experience Questionnaire	Kobeissi, A. H., Lanza, G., Berta, R., Bellotti, F., De Gloria, A. (2018). Development of a Hardware/Software System for Proprioception Exergaming. International Journal of Serious Games, 5(2), 87-100.
P21	GUESS - Game user experience satisfaction scale	Phan, M. H., Keebler, J. R., Chaparro, B. S. (2016). The development and validation of the game user experience satisfaction scale (GUESS). Human factors, 58(8), 1217-1247.
P22	Igroup Presence Questionnaire in Portuguese	Vasconcelos-Raposo, J., Bessa, M., Melo, M., Barbosa, L., Rodrigues, R., Teixeira, C. M. Sousa, A. A. (2016). Adaptation and validation of the Igroup Presence Questionnaire (IPQ) in a Portuguese sample. Presence: Teleoperators and virtual environments, 25(3), 191-203.
P23	ITC - Sense of Presence Inventory (ITC-SOPI)	Lessiter, J., Freeman, J., Keogh, E., Davidoff, J. (2001). A cross-media presence questionnaire: The ITC-Sense of Presence Inventory. Presence: Teleoperators and Virtual Environments, 10(3), 282-297.
P24	MemoLine	Vissers, J., De Bot, L., Zaman, B. (2013, June). MemoLine: evaluating long-term UX with children. In Proceedings of the 12th International Conference on Interaction Design and Children (pp. 285-288).
P25	Networked Minds social presence measure	Biocca, F., Harms, C., Gregg, J. (2001, May). The networked minds measure of social presence: Pilot test of the factor structure and concurrent validity. In 4th annual international workshop on presence, Philadelphia, PA (pp. 1-9).
P26	NO NAME INFORMED	Ravaja, N., Salminen, M., Holopainen, J., Saari, T., Laarni, J., Järvinen, A. (2004, October). Emotional response patterns and sense of presence during video games: Potential criterion variables for game design. In Proceedings of the third Nordic conference on Human-computer interaction (pp. 339-347). ACM.
P27	NO NAME INFORMED	Balducci, F., Grana, C., Cucchiara, R. (2017). Affective level design for a role-playing videogame evaluated by a brain–computer interface and machine learning methods. The Visual Computer, 33(4), 413-427.
P28	NO NAME INFORMED	Moura, D., el-Nasr, M. S., Shaw, C. D. (2011). Visualizing and understanding players' behavior in video games: discovering patterns and supporting aggregation and comparison. In ACM SIGGRAPH 2011 game papers (pp. 1-6).
P29	NO NAME INFORMED	Bailenson, J. N., Swinth, K., Hoyt, C., Persky, S., Dimov, A., Blascovich, J. (2005). The independent and interactive effects of embodied-agent appearance and behavior on self-report, cognitive, and behavioral markers of copresence in immersive virtual environments. Presence: Teleoperators and Virtual Environments, 14(4), 379-393.
P30	NO NAME INFORMED	Fang, X., Zhang, J., Chan, S. S. (2013). Development of an instrument for studying flow in computer game play. International journal of human-computer interaction, 29(7), 456-470.
P31	NO NAME INFORMED	Usoh, M., Arthur, K., Whitton, M. C., Bastos, R., Steed, A., Slater, M., Brooks Jr, F. P. (1999, July). Walking> walking-in-place> flying, in virtual environments. In Proceedings of the 26th annual conference on Computer graphics and interactive techniques (pp. 359-364). ACM Press/Addison-Wesley Publishing Co.
P32	NO NAME INFORMED	Tuch, A. N., Hornbæk, K. (2015). Does Herzberg's notion of hygienes and motivators apply to user experience?. ACM Transactions on Computer-Human Interaction (TOCHI), 22(4), 16.
P33	NO NAME INFORMED	Mania, K., Chalmers, A. (2001). The effects of levels of immersion on memory and presence in virtual environments: A reality centered approach. CyberPsychology and Behavior, 4(2), 247-264.
P34	Playtracer	Andersen, E., Liu, Y. E., Apter, E., Boucher-Genesse, F., Popović, Z. (2010, June). Gameplay analysis through state projection. In Proceedings of the fifth international conference on the foundations of digital games (pp. 1-8).
P35	POGQ - Problematic online gaming questionnaire	Demetrovics, Z., Urbán, R., Nagygyörgy, K., Farkas, J., Griffiths, M. D., Pápay, O., Oláh, A. (2012). The development of the problematic online gaming questionnaire (POGQ). PloS one, 7(5), e36417.
P36	Presence Questionnaire - IMMERSIVE TENDENCY QUESTIONNAIRE	Witmer, B. G., Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. Presence, 7(3), 225-240.

Table 12. Instruments name, paper ID and paper reference.

Paper ID	Name of instrument	Paper Reference
P37	Presence Questionnaire - PRESENCE QUESTIONNAIRE	Witmer, B. G., Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. Presence, 7(3), 225-240.
P38	Presence Questionnaire [modified]	Witmer, B. G., Jerome, C. J., Singer, M. J. (2005). The factor structure of the presence questionnaire. Presence: Teleoperators and Virtual Environments, 14(3), 298-312.
P39	Prov Viewer (Provenance Flux Viewer)	Kohwalter, T. C., Clua, E. G., Murta, L. G. (2013, November). Game flux analysis with provenance. In International Conference on Advances in Computer Entertainment Technology (pp. 320-331). Springer, Cham.
P40	Simulator Sickness Questionnaire (SSQ)	Kennedy, R. S., Lane, N. E., Berbaum, K. S., Lilienthal, M. G. (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. The international journal of aviation psychology, 3(3), 203-220.
P41	Social Presence in Gaming Questionnaire (SPGQ)	De Kort, Y. A., IJsselsteijn, W. A., Poels, K. (2007). Digital games as social presence technology: Development of the Social Presence in Gaming Questionnaire (SPGQ). Proceedings of PRESENCE, 195203, 1-9.
P42	Three-Component Presence Scale	Schubert, T., Friedmann, F., Regenbrecht, H. (2001). The experience of presence: Factor analytic insights. Presence: Teleoperators and Virtual Environments, 10(3), 266-281.
P43	TRUE - Tracking Realtime User Experience	Kim, J. H., Gunn, D. V., Schuh, E., Phillips, B., Pagulayan, R. J., Wixon, D. (2008, April). Tracking real-time user experience (TRUE) a comprehensive instrumentation solution for complex systems. In Proceedings of the SIGCHI conference on Human Factors in Computing Systems (pp. 443-452).
P44	Trust Scale	Wintersberger, P., Frison, A. K., Riener, A., Sawitzky, T. V. (2019). Fostering User Acceptance and Trust in Fully Automated Vehicles: Evaluating the Potential of Augmented Reality. PRESENCE: Virtual and Augmented Reality, 27(1), 46-62.
P45	User Engagement Scale Z (UESz)	Wiebe, E. N., Lamb, A., Hardy, M., Sharek, D. (2014). Measuring engagement in video game-based environments: Investigation of the User Engagement Scale. Computers in Human Behavior, 32, 123-132.
P46	University College London (UCL) questionnaire - shortened version	Meehan, M., Razzaque, S., Whitton, M.C., Brooks, F. P. (2003, March). Effect of latency on presence in stressful virtual environments. In IEEE Virtual Reality, 2003. Proceedings. (pp. 141-148). IEEE.
P47	MEEGA	Savi, R., von Wangenheim, C. G., Borgatto, A. F. (2011, September). A model for the evaluation of educational games for teaching software engineering. In 2011 25th Brazilian Symposium on Software Engineering (pp. 194-203). IEEE.
P48	MEEGA+	Petri, G., von Wangenheim, C. G., Borgatto, A. F. (2016). MEEGA+: an evolution of a model for the evaluation of educational games. INCoD/GQS, 3.
P49	Player Experience Inventory	Abeele, V. V., Spiel, K., Nacke, L., Johnson, D., Gerling, K. (2020). Development and validation of the player experience inventory: A scale to measure player experiences at the level of functional and psychosocial consequences. International Journal of Human-Computer Studies, 135, 102370.
P50	Revised Gameplay Questionnaire	Rivero, T. S.,Pires, E.U., Alves, M.V.C., Silva, J.F., Schlottfeldt, C.G., Bolognani, S.A.P., Bueno, O.F.A. (2016). Translation and cultural adaptation of a questionnaire to evaluate player experience. International Journal of Psychology and Neuroscience, 2(1), 206-234
P51	Immersive Experience Questionnaire (IEQ),	Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., Walton, A. (2008). Measuring and defining the experience of immersion in games. International journal of human-computer studies, 66(9), 641-661.
P52	PENS	Rigby, S., Ryan, R. (2007). The player experience of need satisfaction (PENS) model. Immersyve Inc, 1-22.
P53	Exergames Flow State Questionnaire (EFSQ)	Lai, Y. C., Wang, S. T., Yang, J. C. (2012, July). An investigation of the exergames experience with flow state, enjoyment, and physical fitness. In 2012 IEEE 12th International Conference on Advanced Learning Technologies (pp. 58-60). IEEE.
P54	Gameflow Questionnaire	Sweetser, P., Wyeth, P. (2005). GameFlow: a model for evaluating player enjoyment in games. Computers in Entertainment (CIE), 3(3), 3-3.
P55	Video Game Uses and Gratifications Instrument	Sherry, J. L., Lucas, K., Greenberg, B. S., Lachlan, K. (2006). Video game uses and gratifications as predictors of use and game preference. Playing video games: Motives, responses, and consequences, 24(1), 213-224.
P56	Player Immersion in the Computer Game Narrative	Qin, H., Patrick Rau, P. L., Salvendy, G. (2009). Measuring player immersion in the computer game narrative. Intl. Journal of Human-Computer Interaction, 25(2), 107-133.
P57	Playful Experience Questionnaire (PLEXQ)	Boberg, M., Karapanos, E., Holopainen, J., Lucero, A. (2015, October). PLEXQ: Towards a playful experiences questionnaire. In Proceedings of the 2015 Annual Symposium on Computer-Human Interaction in Play (pp. 381-391).
P58	Exergame Enjoyment Questionnaire (EEQ)	Fitzgerald, A., Huang, S., Sposato, K., Wang, D., Claypool, M., Agu, E. (2020, January). The Exergame Enjoyment Questionnaire (EEQ): An Instrument for Measuring Exergame Enjoyment. In Proceedings of the 53rd Hawaii International Conference on System Sciences.