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Constructs and Outcomes of Fun in Digital Serious Games: The State of the Art

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Abstract

Game design depends not only on understanding the creation process but also the elements that lead the game to be played. Fun, one of these elements, is of important value for the players' enjoyment as well as their experience with the game, particularly with Serious Games (SG) due to its use as an instrument to serious matters. But there is no consensus on what it is and how to create something fun in SG. This paper performs a systematic literature mapping, to answer which are the constructs and outcomes related to fun. Out of 1062 papers, 62 were selected, 19 of which proved a direct impact of some factors on fun. It was found that the research on fun is increasing but slowly, 13 constructs have been proved to yield fun and 17 outcomes were investigated as a result from fun. Along with this, a Fun Framework was created based on related work. However, it was not possible to perceive a trend as to the rationale or form of evaluation focused on fun. Also, it was found that there is no consensual author regarding the definition of fun. The need for more research and discussion about fun, its causes and consequences became clear, despite the lack of a sound definition.

Keywords: *Serious Games, Game Design, Fun, Systematic Literature Mapping.*

1 Introduction

Games are older than human culture, they are intrinsically present in nature and manifest themselves in various ways, such as in law, war, knowledge and poetry, and we naturally get the tension, joy and fun from a game (Huizinga, 2000). Technological advances have enhanced this role and digital games are the most expressive and largest contemporary phenomena in the economic and social context, which often break geographical, political, social, economic, ethical, religious and gender boundaries (Schell, 2010).

Fun has been found to raise players effort and motivation (Ketcheson, Ye and Graham, 2015) and thereby improve results such as performance, sense of reward and enjoyment. In a comparison made by Marsh et al. (2011) it was found that the higher the fun, the greater the player's excitement and attention; in contrast, the lower the fun, the more frustrating and easy to get distracted the game will be.

A more recent and purposedly use of games has led to Serious Games (SG). SG are games with serious intentions whose primary focus is not entertainment, fun or pleasure, which does not mean the absence of these elements but emphasize that the focus of its design has a different purpose (Michael and Chen, 2005). SG are a mental competition, played with a computer, that uses entertainment to promote solutions for various areas, such as government, corporations, education, health, politics, and communication (Zyda, 2005). Some advantages of SG include motivation to undertake treatment, incentive to continue treatment, make it easier to achieve goals, and the possibility to measure progress in rehabilitation (Schroeder and Hounsell, 2016). SG can (Dörner *et al.*, 2016) increase player motivation; make people exercise more; generate interest and curiosity; reach the user's emotional; promote engagement; offer feedback and immediate adaptability; be used as a medical treatment and marketing tool; decrease patient stress and provide balanced cognitive, emotional and physical challenges.

SG is a form of fun, despite the contradiction that games are fun and not serious (Newman, 2004 apud Michael and Chen, 2005). Iacovides and Cox (2015) consider that games that involve serious experiences do not need necessarily to be fun. Games are expected to be fun, albeit, this appeal seems to be diminished when the game is labeled as serious. Shen, Wang, and Ritterfeld (2009) examined seven SGs, and concluded that SGs can be as entertaining as entertainment-only games. They also established thresholds for SGs to be considered acceptable or playable. Whether SG need to be fun is an ongoing debate, but experts consider this element as "important or very important for games as a whole" (Michael and Chen, 2005).

Nevertheless, fun has not been emphasized in most well-known frameworks for designing and analyzing games such as MDA framework (Hunicke, Leblanc and Zubek, 2004) and the Elemental Tetrad (Schell, 2010). These two approaches do not consider fun as their main design element.

Although it is undeniable that people´s emotional, physiological and cultural state might affect the perception of fun, this feature is a major driver for many to use games. Thus, fun needs to be better understood and has been already recognized as one of the grand challenges in game design (Tondorf and Hounsell, 2021). In this context, the lack of clarity on the design elements that lead to fun and the lack of clarity on the outcomes that can be achieved thanks to fun is of particular interest to SG.

The main purpose of this paper is to identify which design elements that lead to fun (its constructs) have been dealt with in the literature on SG and to enumerate the results from a game (serious or not) that is considered fun (its outcomes). To achieve this, we reviewed the literature

regarding the concept and constructs of fun and also we performed a systematic literature mapping in search for the constructs and outcomes. A Fun Framework was created, which summarizes related work illustrating the relationships between fun, its constructs, its outcomes, and player.

2 Fun: Constructs

Some researchers and practitioners have delt with the concept of fun producing interesting arguments so that they started to be considered the basis reference for such. Some well-known authors are presented following. Fun is usually associated with other terms such as intrinsic motivation or enjoyment, as a way to centralize the word and definition, taking a practical approach, only the word "fun" was adopted. There are no well-known authors who focus and discuss the fundamentals of the concept of what fun is in digital games, this research presents authors who comment on fun and are used as a basis for defining fun in digital games.

Cziksentmihalyi presented the concept of flow, which calls for an "optimal experience" to describe it, and which refers to the occasion where we feel a sense of joy, deep pleasure and that we enjoy a certain experience for a long time (Csikszentmihalyi, 1991). Although not based on fun, flow relates to the pleasant sensations we have when playing games.

(Prensky, 2001) argues that games are presented as a form of fun, leading to enjoyment and pleasure as well as part of the learning process, which motivate and promote engagement based on experience. He adds that, fun can be used to improve learning outcomes in educational games.

Blythe et al. (2004) compiled works by several authors on usability and user experience in the area of human-computer interaction, dividing them into theories and concepts, methods and techniques, and; case studies. In their book they discussed about enjoyment, experience, engagement and emotions to design better and more enjoyable products and services. For them, fun and enjoyment are almost synonym. An interesting comparison drawn was fun to pleasure, where pleasure is related to the degree of absorption and fun is related to distraction.

Lazzaro's (2004) work proposed that fun comes from the emotion felt by the player, and this emotion can be divided into 4 groups, as follows: 1. heavy fun, which generates emotions of significant challenges; 2. easy fun, which holds the attention with light elements; 3. altered states, which generates emotion with perception; 4. the people factor, which creates opportunities for interaction with other players.

The MDA Framework (Hunicke, Leblanc and Zubek, 2004) is a formal approach to understand games and it uses a sequential logic where the rules of the game define the game system, and this system leads to fun. The counterparts of this logic in the game design view are mechanics, dynamics and aesthetics. The mechanics are the components of the game, the dynamics are how these mechanics interact which each other in the game and with the player, and the aesthetics are the results delivered as the player's experience. In this case, the rules of the game generate fun, aesthetics, and experience, which groups these elements together as similar.

The Elemental Tetrad (Schell, 2010) is a way to visualize the fundamental elements of a game, with each element having equal importance: mechanics, referring to the rules of the game; narrative, referring to the events that unfold in the game; aesthetics, referring to the appearance of the game; and technology, referring to the materials and interactions that make the game possible. For Schell, fun is pleasure with surprises, it is related to experience and to the act of playing, the two questions related to the lens of fun are “What parts of my game are fun? Why?” and “What parts need to be more fun?” (Schell, 2010).

For Wang, Shen and Ritterfeld (2009) games are expected to be fun, and that fun can depend on the player and the context. Furthermore, fun can be divided, as described by players themselves, into 27 factors, which latter were grouped into 5 major categories:

- Technological Capability;
- Game Design;
- Aesthetic Presentation;
- Entertainment Game Experience;
- Narrative.

Table 1 Lists these fun factors, their identification number (FFid) and gives a quick description for each.

This classification scheme was created by 4 experienced gamers, using inductive and deductive approaches from 60 game reviews by other gamers published on game review websites. Of these 27 factors, the most commented upon were: overall game design, visual presentation, audio presentation, complexity and diversity, and control. In contrast, the least commented factors were fantasy, presence and interactivity.

The authors Wang, Shen and Ritterfeld (2009) perceived some patterns among the 27 fun factors, and with that grouped as follows: gameplay threshold, being the prerequisites for enjoyment, related to technological capability and basic game elements; enjoyment threshold, being the commonly mentioned factors in positive and negative ways, reflecting on the factors related to aesthetic presentation and game design; and the super fun driving factors, derived from the best rated games in the sample these factors are related to extraordinary game design elements, superior quality of aesthetic presentation, but also particularly the role of narrative games and the social interaction of players during and after the game experience. From a game design point of view, the vast majority of factors can be directly changed by developers. However, the most comprehensive factors (marked with * in **Table 1**) are more embracing elements regarding design development.

For Adams (2010), fun is not intrinsic to a game, it is an emotional response to playing the game and tends to suggest excitement and pleasure. However, there are some forms of pleasure that fall under the definition of fun, such as suspense, excitement, exhilaration, and surprise. He shows some aspects that contribute to fun are: avoiding elementary errors; tuning and polishing; imaginative variations on the

game's premise and; true design innovation. But also shows some principles to consider when creating a game with less risk of not being fun: gameplay comes first; get a feature right or leave it out; design around the player; know your target audience; abstract or automate parts of the simulation that aren't fun; be true to your vision; strive for harmony, elegance, and beauty.

Table 1. Fun Factors (Shen, Wang and Ritterfeld, 2009).

FFid	Factors	Description
1	Overall Technological Capacity*	Technological aspects in general.
2	Usability	Functionality and stability of a game.
3	Control	Ease, intuitiveness, and effectiveness of controls.
4	Interactivity	Continuous action and reaction loops between the game world and the player.
5	Artificial Intelligence	Artificial intelligence and its interactions within the game.
6	Overall Game Design*	Overall game design.
7	Novelty	The originality or innovation of a game.
8	Mechanics	Basic game rules and main activities.
9	Complexity and Diversity	Quantity and quality of meaningful options presented to the player.
10	Levels	Game level designs.
11	Challenge	Difficulty and balance of that difficulty of a game.
12	Freedom	Freedom provided by the structure of the game for players.
13	Gratification	Elements of the game that provide a sense of reward.
14	Overall Aesthetic Presentation*	Aesthetic presentation overall.
15	Visual Presentation	Graphical quality of the game.
16	Audio Presentation	Sound quality of the game.
17	Overall Entertainment Game Play Experience*	Overall player experience.
18	Excitement	Rhythm of the game and the sensory pleasure and excitement experienced by the player.
19	Presence	Degree to which the player experiences the game objects as if they were real.
20	Social Interaction	Possibility, the requirement and quality of human interactions.
21	Length	Sufficient duration of the game before it is completed.
22	Replayability	Degree of willingness where one wishes to play the game multiple times.
23	Storyline	Existence and quality of plots and storylines in a game.
24	Characters	Aspects regarding the characters in a game.
25	Humor	Use and effectiveness of humor in a game.
26	Realness	Similarities of the game to the physical world.
27	Fantasy	Fantastic and imaginative experience normally impossible in real life.

Koster (2013) argued that Fun depends on context, it consists mainly of practice and learning. In addition, the fun is defined as the feedback the brain gives when absorbing patterns for learning purposes.

The most detailed list elements that yield to fun was given by Shen, Wang, and Ritterfeld (2009). Therefore, their "fun factors" was the list of constructs initially adopted in this text.

Regardless the fact that fun is innate to games, or not, it is a consensus that fun is a major reason why people play games. Therefore, the better the use of features that lead to fun, the longer games would be played by more people. Thus, game features that lead to fun and the results that can come from it of major importance.

3 Related Work

Four papers were found in the literature by searching academic databases for related secondary papers. These papers were found by searching for fun, fun evaluation methods and games. They were selected because they discuss, and present results related to the objective of this study.

The systematic literature review carried out by Petri and von Wangenheim (2016) searched for evaluation methods for educational games. Out of 11 papers, 3 considered fun as a factor in the evaluation, and fun was just one among 53 factors considered in the papers.

The systematic review presented by Yanti, Rosmansyah and Dabarsyah (2019) searched for SG for children, identifying characteristics and technologies used. It was found that some of the characteristics of SG affect learning in children, characteristics such as fun, performance, engagement, and motivation.

The systematic review done by Normal, MdNor, and Ishak (2014) focused on identifying beliefs regarding fun in digital games from a human nature perspective. They concluded that opinions regarding fun are a complicated set of circumstances caused by currently poorly understood mechanisms. These opinions are closely related to human affairs and human diversity.

The work of Borges et al. (2020) discussed methods for evaluating the player experience in the academic context, besides presenting the various definitions regarding usability, user experience and player experience contained in the literature. Out of the 47 evaluation artifacts, only 1 had player fun as an evaluated element: MEEGA+ (Petri, Wangenheim and Borgatto, 2019);

These papers demonstrate that fun has been considered a research topic sought by players and game developers. Yet, fun does not have a clear definition, outcomes or form of evaluation that is widely used. For this reason, a review of the literature is necessary to better explore these issues.

4 FUN: Outcomes & Research

A Systematic Literature Mapping has several objectives, such as (Kitchenham and Charters, 2007): examining the extent and nature; determining the value; summarizing and disseminating the results, and; identifying research gaps. This paper seeks to answer several questions regarding fun in serious games and we adopted the guidelines for a systematic literature mapping given by Petersen, Vakkalanka and Kuzniarz (2015), as follows.

4.1. Research questions

The primary research question (PQ) is:

PQ: What is the research status regarding fun in Serious Games (SG)?

Secondary research questions (SQ) are:

SQ 1: What are the creation, design, and development aspects related to fun?

SQ 2: How fun has been evaluated?

SQ 3: Which authors discuss fun in SG?

SQ 4: What are the most usual constructs and outcomes of a fun SG?

4.2. Search Sources

Among the most featured academic search engines (ASE) (Buchinger, Cavalcanti and Hounsell, 2014) we have chosen the following: IEEE Xplore, ACM Digital Library and Science Direct. They all comply to areas related to games design and use. The search was also performed in the proceedings of all tracks of the Brazilian Symposium of Games and Digital Entertainment (SBGames) because it is one of the largest events in the area in Latin America and because it is a specific forum. In addition, the search was performed on regular issues of the Journal on Interactive Systems (JIS), which is the main Brazilian journal to include games in its scope.

The search was carried out between May and June of 2021 in ASE data bases and; between November and December of 2021 for SBGames and JIS databases. The access was through the academic logging in the CAPES[1] portal, and the mapping results were managed using JabRef[2] for organizing the search results, Mendeley[3] for organizing the citations, and MS Excel[4] for extracting, archiving, and tagging the data.

In Portuguese the word fun comes from the Latin *diversĭo* and has as meaning, to be the act or effect of amusing, pastime, recreation, recreation, is the change or detour of attention, a distraction (Melhoramentos, 2021). Also, the word fun originates from the Middle English 'fool' and pleasure from the Gaelic language, and is also defined as a source of pleasure, being a function of the brain feeling good by releasing endorphin (Koster, 2013). In this text the words fun and enjoyment are considered almost synonym, although we recognize that other words have been associated with fun. But they are all different, therefore only the word "fun" will be searched for.

To create the search string, preliminary tests were performed, as well as iterations to evaluate the quality and focus of the results. The search string, was refined using groups of key words following the pattern: (research focus) AND (development methods) AND (project intentionality) AND (relationship to games). Portuguese words were used for the base string only in SBGames.

To apply the search string, based on the base pattern, four strategies were used. Also, one was used for later conference. These strategies are all described in **Table 2.**

Table 2. Search strategies used.

Id	String	Database
a)	(Fun) AND (Design* OR Develop*) AND (Serious OR Educati* OR Appl*) AND (Game*)	ACM DL, IEEE Explore
b)	(Fun) AND (Design OR Develop OR Development OR Developed) AND (Serious OR Educational OR Applied) AND (Game)	Science Direct
c)	("fun" OR "fun." OR "fun," OR "fun:" OR "fun;" OR "fun" OR " fun" OR Diversão OR Divertido)	SBGames
d)	("fun" OR "fun." OR "fun," OR "fun:" OR "fun;" OR "fun" OR " fun") AND (Games OR Game)	JIS
e)	("fun " OR "fun." OR "fun," OR "fun:" OR "fun;" OR diversão OR divertido) AND (Design* OR Develop* OR Desenv*) AND (Serio* OR Educa* OR Appl* OR Aplic*) AND ("games" OR "game")	SBGames, JIS

The search string was adapted according to the limitations and resources of each ASE. The search was done at the title, keywords and abstract. Due to the number of boolean operators limitations in IEEE Xplore it was necessary to perform 3 searches, one for each group of the topic, the results of the 3 searches were added and duplicates were removed. The Science Direct ASE does not provide support for wildcards, that's why the (b) strategy search string included word flexions.

[1] https://www.periodicos.capes.gov.br

[2] https://www.jabref.org

[3] https://www.mendeley.com

[4] https://www.microsoft.com/pt-br/microsoft-365/excel

SBGames and JIS do not have an ASE. For SBGames it was necessary to download all the Proceedings (2010-2021), where all Full Papers were selected, totaling 1260 files. For JIS all papers were downloaded from Archives of regular issues, totaling 117 files from 2010 to 2021. With the help of the Agent Ransack[1] software papers from SBGames and JIS were locally filtered according to the search string created for each. The (c) search strategy was composed so that words that contained "fun" in the middle, such as "function" or "confundir", would not appear in the results. Also, we added the words “Diversão” and “Divertido” to the Agent Ransack string, since SBGames has papers in Portuguese. “Games” or “Game” were also added to the (d) search string. The search, after Agent Ransack, resulted in 571 papers for SBGames and 25 for JIS.

In a late check, after the filtering performed to select the papers, the search phrase (e) was applied on top of the JIS and SBGames files to check if any paper did not comply the base search phrase and also comply serious games. None of the papers were excluded in this step.

4.3. Selection Criteria

In this filtering phase of the protocol, Objective Criteria (OC); Subjective Exclusion Criteria (EC), and; Subjective Inclusion Criteria (IC) were defined, which were used to select which papers are relevant for this research.

The following OCs were used to select the papers:

OC1: Published between 2010-2021;

OC2: Written in English (or Portuguese in the case of SBGames);

OC3: From events or journals (peer-reviewed);

OC4: Full papers (more than 4 pages);

OC5: Available through CAPES journal portal or free (open access);

OC6: Primary/original papers (not a review, nor similar);

OC7: Non-duplicate papers.

Each ASE has filtering features, such as year or language for example. Some OC filtering was available in each. Other criteria that were not automated via the ASE's filtering capabilities, such as OC6 and OC7, were filtered manually by the researchers.

The ECs and ICs were defined as:

EC1: Papers not related to digital games;

EC2: Papers that do not address design, creation, or development aspects;

EC3: Papers focused only on gamification;

IC: Papers must present a focus on measuring or concluding something about fun.

A pilot test was performed with the ASE that presented the lowest number of results with the base search string and the OCs. After adjustments the protocol as presented was applied to all other ASEs.

To perform the selection, each criterion was applied to all papers then the next criteria, starting with the OCs, then the ECs, and finally IC. For exclusion at each step, each paper was checked for title, keywords, abstract, and lastly by full reading as needed.

4.4. Data Extraction and Classification

This step focused on extracting the information from each paper. After initial tests and analysis, data gathering that would help answer PQ and SQs were defined. These data were divided according to groups: meta data, such as title and authors; fun, with information on authors, constructs and outcomes related to fun; instruments, with the comparison elements and metrics, and; evaluation, with results from tests with instruments.

5 Results

Table 3 contains the number of results for each filtering stage, from the base search string to OCs, ECs and IC.

Table 3. Quantities of papers identified

	JIS	SBGAMES	IEEE	ACM DL	Science Direct	Total
Base String	25	571	228	194	44	**1062**
OCs	21	547	140	80	23	811
ECs	21	493	103	41	13	671
CI	2	27	20	11	2	**62**

In the end, 62 papers were selected (Albuquerque and Fialho, 2010; Doucet and Srinivasany, 2010; Froschauer *et al.*, 2010; Petry, 2010; Jovanovic *et al.*, 2011; Marsh, 2011; Marsh *et al.*, 2011; Freitas *et al.*, 2012; Marques, Levitt and Nixon, 2012; Ouherrou *et al.*, 2012; Carvalho and Ishitani, 2012; Cuperschmid and Hildebrand, 2013; Franzwa, Tang and Johnson, 2013; Alves and Santos, 2013; Bonnet, Lotte and Lécuyer, 2013; Van de Laar, Bos, *et al.*, 2013; Van de Laar, Gürkök, *et al.*, 2013; Joselli *et al.*, 2014; Machado, 2014; Medeiros and Medeiros, 2014; Menezes and Schlemmer, 2014; Su and Wu, 2014; Torok *et al.*, 2014; Alves and Borges, 2015; Iacovides and Cox, 2015; Ketcheson, Ye and Graham, 2015; Lindberg, Seo and Laine, 2016; Ooi *et al.*, 2016; Sobrinho *et al.*, 2016; Venter and De Wet, 2016; Krause *et al.*, 2017; Leite and Almeida, 2017; Petri, von Wangenheim and Borgatto, 2017; Satria *et al.*, 2017; Clemes *et al.*, 2018; Lorenzi, Ribeiro and Kurtz, 2018; Majid *et al.*, 2018; Maqsood, Mekhail and Chiasson, 2018; Rachevsky, de Souza and Nedel, 2018; Silva Bastos *et al.*, 2018; Silva *et al.*, 2018; Carneiro *et al.*, 2018; Garry *et al.*, 2019; Jesus and Silveira, 2019; Karácsony *et al.*, 2019; Kolthoff, Spil and Nguyen, 2019; Oliveira *et al.*, 2019; Brito *et al.*, 2019; Souza *et al.*, 2019; Warriar, Woodward and Tokarchuk, 2019; Ihsan, Herumurti and Yunanto, 2020; Lam *et al.*, 2020; Moosa *et al.*, 2020; Nascimento, 2020; Rodrigues, Bonidia and Brancher, 2020; Cardozo *et al.*, 2020; Zamith *et al.*, 2020; Cardozo *et al.*, 2021; Jhones *et al.*, 2021; Bragg *et al.*, 2021; Pereira, Viana and Toledo, 2021; Umbelino and Mota, 2021).

[1] https://www.mythicsoft.com/agentransack/

Figure 1 shows the number of selected papers per year, as well as the linear regression line, which shows an increase on the number of papers published over the last ten years. SBGames was the database with the highest number of selected papers (43.5%).

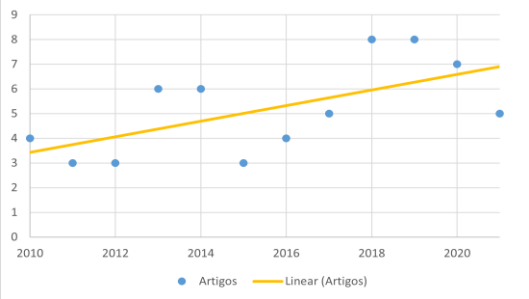

Figure 1. Selected papers over the years.

The Fun Factors (Shen, Wang and Ritterfeld, 2009) were adopted to identify which of them are most studied in the literature. They were accounted for by analyzing the descriptions given in the papers in search of which factors were most used or commented. We considered the discourse of the papers' authors themselves or the reports of the research participants on the papers' text. These results can be seen in **Figure 2** where in the left side are the FFid and the fun factor label as used in **Table 1** and, in the right side are the number of papers that have commented on each construct/fun factor.

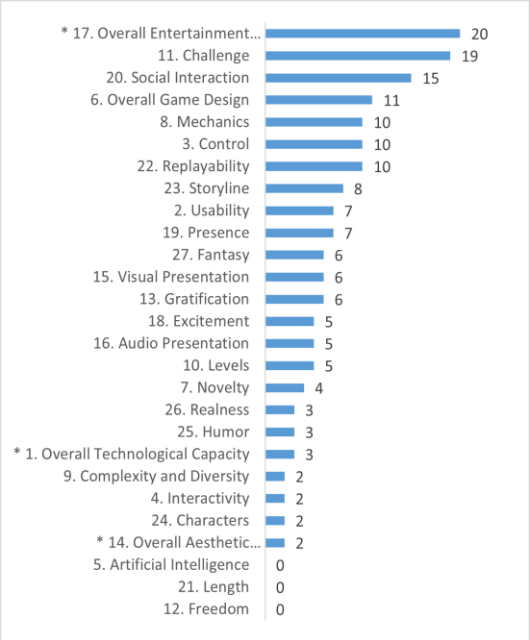

Figure 2. Frequency of the fun factors (constructs) in the papers.

Among the 62 papers, 19 somehow proved the impact on fun in a direct way, and 7 of these papers presented several studies with different results (by using various test groups). For instance, (Bonnet, Lotte and Lécuyer, 2013) presented 3 test groups; and, (Rachevsky, de Souza and Nedel, 2018) and (Marsh *et al.*, 2011) presented 4 test groups. On the other hand (Van de Laar, Bos, *et al.*, 2013) and (Van de Laar, Gürkök, *et al.*, 2013) presented various results regarding fun by using only one test group. In addition we obtained 11 papers (Joselli *et al.*, 2014; Medeiros and Medeiros, 2014; Menezes and Schlemmer, 2014; Torok *et al.*, 2014; Ketcheson, Ye and Graham, 2015; Silva *et al.*, 2018; Souza *et al.*, 2019; Zamith *et al.*, 2020; Lam *et al.*, 2020; Rodrigues, Bonidia and Brancher, 2020; Pereira, Viana and Toledo, 2021) that proved the increase in fun. One paper (Iacovides and Cox, 2015) proved the decrease in fun, where the determining factors for the decrease of fun was realism - related mainly to factors "23. Storyline" and "26. Reality", as well as to factors "17. Overall Intendment Game Experience" and "6. Overall Game Design".

Only a few papers presented evidence of some construct that affect the perceptions of fun (see in **Table 4**).

Table 4. Evidences of constructs that drive the perception of fun

Control device	(Joselli *et al.*, 2014; Torok *et al.*, 2014; Ketcheson, Ye and Graham, 2015; Silva *et al.*, 2018)
Balancing Level	(Medeiros and Medeiros, 2014; Zamith *et al.*, 2020; Pereira, Viana and Toledo, 2021)
Control	(Van de Laar, Bos, *et al.*, 2013)
Rewards	(Ketcheson, Ye and Graham, 2015; Warriar, Woodward and Tokarchuk, 2019)
Competitiveness	(Garry *et al.*, 2019)
Difficulty	(Garry *et al.*, 2019)
Immersion	(Rachevsky, de Souza and Nedel, 2018)
Mechanics	(Rodrigues, Bonidia and Brancher, 2020)
Multi-user	(Bonnet, Lotte and Lécuyer, 2013)
Narrative	(Marsh *et al.*, 2011)
Physical Effort	(Ketcheson, Ye and Graham, 2015)
Unpredictability	(Lam *et al.*, 2020)
Use of Virtual World	(Souza *et al.*, 2019)

Although these results are related to game elements, they are generally considered to be part of the overall game experience, thus attributing fun as one of the present elements of the experience when playing. It was observed that the constructs found that were effectively related for fun do not coincide with the fun factors listed initially.

The papers that considered on the largest number of constructs were (Albuquerque and Fialho, 2010), (Jovanovic *et al.*, 2011) and (Machado, 2014) dealing with on 9, 8 and 7 constructs, respectively.

The data on the outcomes of fun studied in the papers can be seen in **Table 5**, which also includes other well-known papers highlighted in bold.

Regarding the types of instruments used for the evaluation, we have obtained, 48 papers that used questionnaires, 7 (Albuquerque and Fialho, 2010; Petry, 2010; Jovanovic *et al.*, 2011; Marsh, 2011; Machado, 2014; Leite and Almeida, 2017; Umbelino and Mota, 2021) did not use evaluation in their papers; 6 (Marsh *et al.*, 2011; Carvalho and Ishitani, 2012; Menezes and Schlemmer, 2014; Lindberg, Seo and Laine, 2016; Kolthoff, Spil and Nguyen, 2019; Oliveira *et al.*, 2019) used interviews; 1 (Satria *et al.*,

2017) used observation and; 1 (Cuperschmid and Hildebrand, 2013) used heuristic evaluation. These data corroborate Barbosa *et al.* (2021) that stated that questionnaires are the most usual type of evaluation.

Table 5. Outcomes of fun commented in the papers

Learning	(Petry, 2010; Doucet and Srinivasany, 2010; Froschauer *et al.*, 2010; Marsh *et al.*, 2011; Ouherrou *et al.*, 2012; Menezes and Schlemmer, 2014; Machado, 2014; Satria *et al.*, 2017; Krause *et al.*, 2017; Carneiro *et al.*, 2018; Clemes *et al.*, 2018; Brito *et al.*, 2019; Jesus and Silveira, 2019; Cardozo *et al.*, 2020; Moosa *et al.*, 2020; Cardozo *et al.*, 2021) (in addition to (Yanti, Rosmansyah and Dabarsyah, 2019) already known)
General Experience	(Jovanovic *et al.*, 2011; Cuperschmid and Hildebrand, 2013; Franzwa, Tang and Johnson, 2013; Clemes *et al.*, 2018; Souza *et al.*, 2019; Moosa *et al.*, 2020; Rodrigues, Bonidia and Brancher, 2020; Bragg *et al.*, 2021; Umbelino and Mota, 2021)
Engagement	(Franzwa, Tang and Johnson, 2013; Menezes and Schlemmer, 2014; Venter and De Wet, 2016; Krause *et al.*, 2017; Satria *et al.*, 2017; Carneiro *et al.*, 2018; Maqsood, Mekhail and Chiasson, 2018; Nascimento, 2020)
Motivation	(Freitas *et al.*, 2012; Bonnet, Lotte and Lécuyer, 2013; Ketcheson, Ye and Graham, 2015; Venter and De Wet, 2016; Clemes *et al.*, 2018; Majid *et al.*, 2018)
Willingness to play again	(Oliveira *et al.*, 2019) and (Read and MacFarlane, 2006; Moser, Fuchsberger and Tscheligi, 2012)
Curiosity	(Ooi *et al.*, 2016; Garry *et al.*, 2019; Lam *et al.*, 2020)
Difficulty	(Van de Laar, Bos, *et al.*, 2013; Medeiros and Medeiros, 2014; Garry *et al.*, 2019)
Emotional reactions	(Iacovides and Cox, 2015; Lorenzi, Ribeiro and Kurtz, 2018; Umbelino and Mota, 2021)
Collaboration	(Menezes and Schlemmer, 2014; Jesus and Silveira, 2019)
Enjoyment	**(Prensky, 2001; Blythe *et al.*, 2004)**
Pleasure	**(Prensky, 2001; Blythe *et al.*, 2004)**
Satisfaction	(Su and Wu, 2014; Pereira, Viana and Toledo, 2021)
Tension	(Jovanovic *et al.*, 2011; Umbelino and Mota, 2021)
Attention	(Joselli *et al.*, 2014)
Confidence	(Satria *et al.*, 2017)
Distraction	**(Blythe *et al.*, 2004)**
Frustration	**(Blythe *et al.*, 2004)**

We found a plethora of instruments to measure fun such as, the Fun Tolkit (FT) (Read and MacFarlane, 2006); MEEGA/MEEGA+ (Petri, Wangenheim and Borgatto, 2019); ESFQ (Moser, Fuchsberger and Tscheligi, 2012); GEQ (Ijsselsteijn, Kort and Poels, 2013); 4 AFC (Mandryk and Atkins, 2007), PQ (McCall, O'Neil and Carroll, 2004) and; GameFlow (Sweetser and Wyeth, 2005).

As for the scales used to evaluate fun, several different types were identified, such as binary metrics (yes or no); ternary (yes, so-so or no; yes, no or maybe.); numerical scales (from -2 to +2, from -5 to +5, from 1 to 2, from 1 to 5, from 1 to 10, from 0 to 100, from 0 to 7); and descriptive answers. A graphical scale was also used when children were involved. Data from the control devices were also taken from the papers, not as a result of the fun but as data for comparison. The graph referring to the control devices can be seen in **Figure 3**. We can see the use of atypical controls, such as the Brain Computer Interface (BCI), which is a control device that uses brain waves, sensors, movement and heart rate reading, and, according to these papers, the fun came from the control devices.

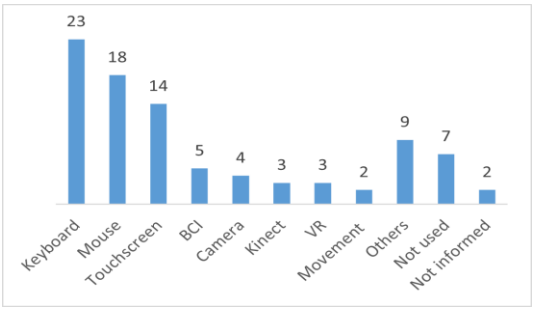

Figure 3. Control Devices.

Examples of atypical controls include: The camera was used to see the game world in a AR environment (Warriar, Woodward and Tokarchuk, 2019) and used to read hand signals (Bragg *et al.*, 2021); the BCI was used to see the control of player mental state as a input for the game (Van de Laar, Gürkök, *et al.*, 2013; Joselli *et al.*, 2014), and; Wearable inertial measurement units was used to get the position of hands as arms in a VR ping-pong game (Silva *et al.*, 2018);

Figure 4 Shows the age range studied, if a paper studied subjects aged 18 to 60 years, it was considered to fall into 4 different categories. In **Figure 3** and **Figure 4,** "Not used" accounts for papers that did not used any type of evaluation in a game or its mechanics. Instead, these papers simply discussed about fun.

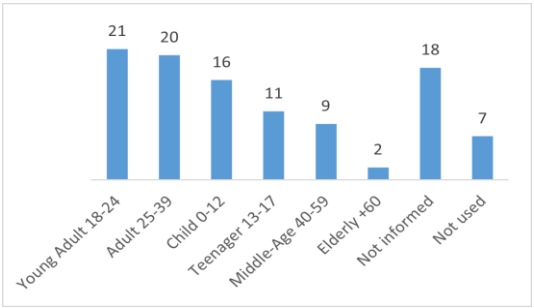

Figure 4. Evaluated Age Group.

The median number of subjects in the experiments was 20, and ranged from 1 (Majid *et al.*, 2018) to 500 (Rodrigues, Bonidia and Brancher, 2020) in studies with 1 game, and 723 in the studies with 20 games (Petri, von Wangenheim and

Borgatto, 2017). Regarding the evaluated context (see **Figure 5**), 31 papers (Doucet and Srinivasany, 2010; Froschauer *et al.*, 2010; Marsh *et al.*, 2011; Marques, Levitt and Nixon, 2012; Alves and Santos, 2013; Franzwa, Tang and Johnson, 2013; Menezes and Schlemmer, 2014; Su and Wu, 2014; Alves and Borges, 2015; Iacovides and Cox, 2015; Ketcheson, Ye and Graham, 2015; Lindberg, Seo and Laine, 2016; Ooi *et al.*, 2016; Sobrinho *et al.*, 2016; Venter and De Wet, 2016; Krause *et al.*, 2017; Petri, von Wangenheim and Borgatto, 2017; Satria *et al.*, 2017; Lorenzi, Ribeiro and Kurtz, 2018; Maqsood, Mekhail and Chiasson, 2018; Carneiro *et al.*, 2018; Clemes *et al.*, 2018; Jesus and Silveira, 2019; Brito *et al.*, 2019; Oliveira *et al.*, 2019; Souza *et al.*, 2019; Moosa *et al.*, 2020; Rodrigues, Bonidia and Brancher, 2020; Cardozo *et al.*, 2020; Zamith *et al.*, 2020; Cardozo *et al.*, 2021) were related to education.

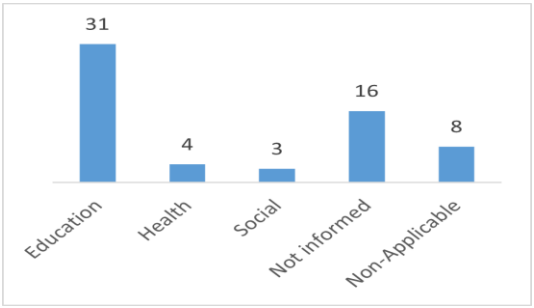

Figure 5. Paper's Context.

Regarding the characteristics of the subjects, most of them were students, and the rest was divided into people with or without experience in a certain discipline (Froschauer *et al.*, 2010; Bonnet, Lotte and Lécuyer, 2013; Iacovides and Cox, 2015; Venter and De Wet, 2016; Warriar, Woodward and Tokarchuk, 2019; Ihsan, Herumurti and Yunanto, 2020) and; with or without motor or cognitive limitations (Ouherrou *et al.*, 2012; Majid *et al.*, 2018; Rachevsky, de Souza and Nedel, 2018; Bragg *et al.*, 2021).

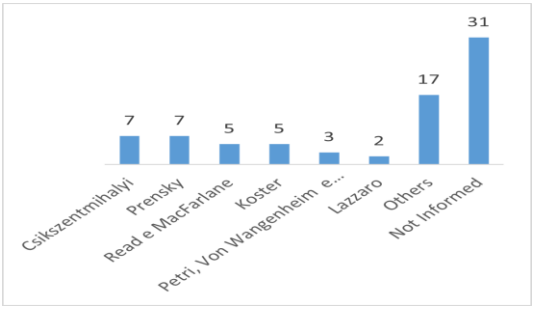

Figure 6. Authors Cited as a Basis for Fun.

Figure 6 shows that most papers did not bother to present a sound foundation for fun, or were based on papers that were not actually focused on fun. Seventeen authors were cited just once among all 62 selected papers including Mandryk and Atkins (2007), Wang, Shen and Ritterfeld (2009) and Adams (2013). Among the authors cited as a basis for fun, 3 were related to evaluation methods (Read and MacFarlane, 2006; Mandryk and Atkins, 2007; Petri, von Wangenheim and Borgatto, 2017) and the Fun Toolkit was the most frequent evaluatiom method. Some of the selected papers were based on more than one basis author. It should be highlighted that some of basis authors found in the papers argued that fun is a cause and some argued that fun is a consequence of a game feature. Most cited basis authors actually are not mainly concerned with fun but other subjects such as happines (Csikszentmihalyi, 1991) and learning (Prensky, 2001).

6 Discussion

A comparison of the results with related papers points to problems already raised. There were few evaluation instruments that focus on fun, and those who evaluate it used a questionnaire to as a few aspects related to fun, as can be seen in Borges et al. (2020) and Petri and von Wangenheim (2016). Fun remains complex and poorly understood, as previously stated by Normal, MdNor, and Ishak (2014), and there is a miryad of characteristics that are affected by fun as commented by Yanti, Rosmansyah and Dabarsyah (2019).

Once the set of features that leads to a fun serious game do not coincide with the set of fun factors, we can see that these lists (**Table 1** and **Table 4**) are not complete in order to understand everything that results in (more) fun. Also, it could be seen (**Figure 6**) that authors cited by the papers were not always those that specifically delve into fun. In most of the papers, the authors presented as a foundation were related to the evaluation or development instruments. The majority of the papers do not present a sound foundation regarding fun.

It was found that most papers consider fun as something commonly accepted and without the need to be previously defined. This may be related to intrinsic motivation, where players play because they want to play and, have fun because they want to have fun. Although fun is something of a common-sense, not being defined can be a scientific problem, making it difficult to pinpoint what to study when talking about fun. This fact shows a need in defining fun in general, being possible to measure it widely in games.

Some papers defined fun as an element within the game experience, relating to FFid number 17 (see **Table 1**) of Wang, Shen and Ritterfeld (2009) which contemplates the experience in general. The constructs 17 (Overall Entertainment Game Play Experience), 20 (Social Interaction), 8 (Mechanics) and 11 (Challenge), respectively, were the ones most frequently considered (as presented in **Figure 2**). Construct 17 is related to a general way on how the player experiences the game and is comprehensive and subjective, so it may not be very pratical to developers, since the experience may vary according to the player and is related to several other constructs. Constructs 20, 8 and 11 are more tangible for developers, as they can be directly changed through game mechanics and elements: Construct 20 is related to social interaction, the ways players interacts with each other; construct 8 covers the basic rules of the game, in this case the possibilities that the player has available, and; construct 11 is related to the difficulty of the game, being the way the player interacts with the game and progresses in it. Besides being able to be altered directly by developers we can see that these factors

(20, 8, 11) are intrinsically linked to each other, therefore one can alter the other's perception of fun.

Studies with usual devices (keyboard, mouse, touchscreen) were the most frequent (see **Figure 3**). However, other devices, such as BCI and heart rate related ones, were considered as a determining factor for fun. For instance, in (Ketcheson, Ye and Graham, 2015), heart rate measured by player's physical effort in a pedal of a stationary bicycle was correlated to a funnier serious game.

Regarding the forms of evaluation, it was found that the main form used was by using a questionnaire with a numerical scale. This is due to the ease of answering for inexperienced respondents such as children as demonstrated in the Fun Toolkit. Other metrics found were subjective, which depend on how it is described by the evaluator, changing according to the experience in games, writing or speaking skills.

Only 1 of the instruments presented is focused on fun, but this instrument was developed for children. Questions regarding fun varied considerably among instruments (**Table 6)**. In addition, the answers given by the instruments are generally ordinal and general, not indicating why the game is fun.

Table 6. Questioning used to measure Fun

Instrument	Format/Phrase	Answers
FT (Read and MacFarlane, 2006)	Smileyometer; Fun Sorter; Again - Again table.	Awful to Briliant (1 a 5); Best to Worst; Yes, Maybe and No.
MEEGA (Petri, Wangenheim and Borgatto, 2019)	I had fun with the game; Some situation happened during the game (game elements, competition, etc.) that made me smile. (our translation)	Strongly disagree to strongly agree (1 to 5) (our translation)
ESQF (Moser, Fuchsberger and Tscheligi, 2012)	How much did you like the game?	"yawn, boring" to "yeah, fun" (1 to 5)
GEQ (Ijsselsteijn, Kort and Poels, 2013)	I thought it was fun	"not at all" to "extremely" (0 to 4)
4 AFC (Mandryk and Atkins, 2007)	Galvanic skin response, electrocardiography, electromyography of the face, heart rate.	67 Rules, 10 of them related to fun (not only)
PQ (McCall, O'Neil and Carroll, 2004)	How involved were you in the virtual environment experience?	"not" to "very" (1 to 7)
GameFlow (Sweetser and Wyeth, 2005)	Learning the game should not be boring, but part of the fun	1 – not at all to 5 – well done

Seven papers did not use any instruments to evaluate fun. Instead, they simply discussed about it. Jovanovic et al. (2011) divided fun into 2 poles (pleasure and desire) with the resultant of these two poles being play tension. Marsh (2011) presented a continuum of SG where the greater the fun the closer to a game the project will be. On the other hand, Leite and Almeida (2017) presented an artifact-experience model where gameplay is directly related to game experience, and therefore to fun. Umbelino and Mota (2021) explored the negativity valanced emotions, and how these emotions create a meaningful game and Petry (2010) discussed about the philosophy to comprehend what a game is. These papers, despite presenting conclusions and discussions about fun, do not focus particularly on fun.

Out of the results, only two papers discussed particularly about fun: Machado (2014) discussed about the fun factor in an educational game, showing what is a game, the rules of a game, motivations to play and about the learning process. He also concluded that the main characteristics taken into account when creating a fun and educational game are fantasy, challenge, mastery, reward, constant evolution, flow, and immediate feedback. Another important point raised by him is that the project must have partnerships that involve professionals from various related areas, such as teachers, designers and psychologists, so that the game is not just a series of interactive content or just a fun game.

Albuquerque and Fialho (2010) presented a review about approaches that seek to understand or deepen the fun in digital games. They demonstrated and discussed partcularly about fun in academic and non-academic environments. They presented thoughts about what fun is, by presenting related papers that discussed: experience, human and social sciences; the design, experience and games; fun in game design, and; research on games. Besides that, they have also presented a series of factors related to fun.

7 FUN Framework

Figure 8 present a framework that gathers what was found scattered all over the selected papers. It does not mean that we agree with it completely. Rather, we highlight this framework as a reference model for further research to confirm/refute relationships.

The left side of this framework groups issues related to game design, such as elements and constructs that are perceived by the player. These elements are considered to cause fun, which is a form of experience received when playing the game. Because they generate fun, how to select, interconnect and deliver them to the player is essential. In the fun (central) part, elements such as context (Koster, 2013) and people (Lazzaro, 2004) can influence fun, and fun is intrinsic to the player and, each player will have his or her own fun experience. Feelings like pleasure, for example, can be confused with, or considered similar to, fun and they should be recognized but differentiated. Outcomes are the results that can be observed because of achieving fun. Outcomes can be increased engagement, enjoyment, and motivation, for example.

Among the constructs related to fun that have been proposed by researchers and developers, we have adopted the fun factors presented by Wang, Shen and Ritterfeld (2009) (**Table 1**) as well as the constructs presented in **Table 4**. The

game design elements shown can be divided into 5 categories (technology, aesthetics, design, experience and narrative), which alter the player's perception of the game making him have different emotions as s/he plays.

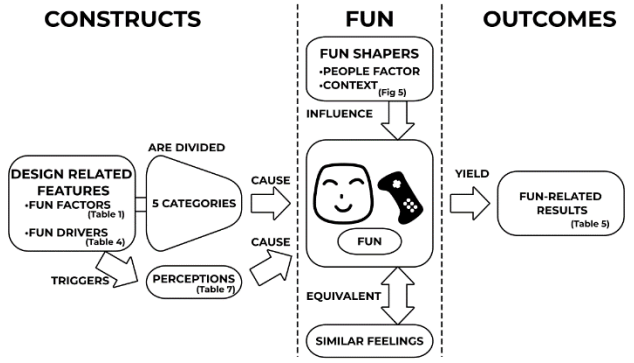

Figure 8. Fun Framework.

By analyzing existing instruments that include measuring fun we found several perceptions or reactions related to fun, that can be seen in **Table 7**. These perceptions are effects that games have on players that can be perceived externally (by another person) and internally (by the player himself). They are related to how the player perceives the game, and this perception generates the cause of the player's fun.

Table 7. Perceptions or reactions related to fun

Smiling	(Mandryk and Atkins, 2007; Petri, Wangenheim and Borgatto, 2019)
Boring, Monotonous and Tedious	(Moser, Fuchsberger and Tscheligi, 2012)
Brilliant, Genius and Wonderful	(Read and MacFarlane, 2006);
Cool and Good	(Koster, 2013; Petri, Wangenheim and Borgatto, 2019);
Terrible and Horrible	(Read and MacFarlane, 2006)
Happy	(Ijsselsteijn, Kort and Poels, 2013; Petri, Wangenheim and Borgatto, 2019)

Fun is something personal, and therefore depends on the player and the context (Koster, 2013). The player feels the emotion that leads to fun, where these emotions can be divided into 4 types (heavy fun, easy fun, altered states and people factor) (Lazzaro, 2004). In the same way, we have similar feelings that can be related as equivalent to fun, such as entertainment, amusement, enjoyment, excitement, trick and pleasure.

As outcomes, several sensations and actions can be yielded when playing and having fun with a game, those resulting from this research can be seen in **Table 5**, but others can be added such as: enjoyment and pleasure (Prensky, 2001; Blythe *et al.*, 2004); frustration, distraction (Blythe *et al.*, 2004), and will to play again (Read and MacFarlane, 2006; Moser, Fuchsberger and Tscheligi, 2012) already inserted in in **Table 5**.

8 Threats to Validity

It is possible that some relevant papers were not included mainly because of limiting the search to the specific word "fun". However it was done to establish a specific focus.

The second author helped determine the whole protocol and act as a referee to final decisions on inclusion and exclusion criteria and final interpretations. The first author performed all initial screening, selection and data gathering. To reduce the risks, the results were double checked during the process for errors. The selected papers were reviewed a third time to confirm the data and to look for errors. In addition, during the writing and revision of this text some possible misunderstandings were discussed and corrected, if necessary.

9 Conclusion

This paper searched for information in the literature about fun in digital games. As a result, out of 1062 candidates, 62 relevant papers were selected.

Among the factors of fun found in the papers, the second and third most frequent results (Challenge and Social Interaction) can be changed individually by the developers as a mechanic in the design. The other most frequent factor depends on changing a whole set of related elements (factor Overall game entertainment experience). This one is related to the overall experience and is more complex than a single mechanic.

It was found that there is a mismatch between theory and practice in the area because the existing theoretical constructs (**Table 4**) do not coincide with the constructs that were initially enumerated (**Table 1**). Also, authors who have specifically focused on fun do not coincide with the authors used to support the actual research on the subject.

Regarding the Secondary Questions, it can be said that little about fun games creation and development (SQ 1) has been found and most papers showed finished or almost finished games than initial development projects. Regarding the forms of evaluation (SQ 2), there were various types of evaluation where most papers used questionnaires and a numerical scale to evaluate fun. In addition, the systematic literature mapping identified 7 instruments used to evaluate fun. There were few authors cited as a basis for fun (**Figure 6**), and the proportion of authors discussing the concept of fun (SQ 3) was relatively low compared to the whole sample. Regarding the constructs and results of fun (SQ 4), it was possible to determine the frequency of the fun factors (**Figure 2**), constructs that lead to fun (**Table 4**), and the results of fun (**Table 5**).

It can be concluded that fun is a particular feeling that arises from playing. It is innate to games, being serious games or not. Fun is a complex matter because it is dependent on game design as well as on people, context and others less-technical issues. Nevertheless, fun is different from joy, pleasure, satisfaction, engagement and other closely related terms. Furthermore, there are some aspects that do influence the perception of fun and, there are some

outcomes that can be emphasized when achieving a fun serious game.

A Fun Framework was build based on all related work that can be used as an initial reference model to reason and to research on fun in digital SG.

In summary it can be concluded that:

- Fun seems to be a consensus as an important feature of a (serious) game;
- The list of fun constructs goes much beyond what initially enumerated as the fun factors - (Wang, Shen and Ritterfeld, 2009);
- There is a list of fun outcomes that are (almost) consensual but just a few of them have been tested;
- There is a need for more research on the topic, either towards constructs, for design sake, as well as towards outcomes, for utility sake;

As future work researchers could test the hypothesis that some constructs (either fun factors, fun drivers or perceptions) do cause fun in SG. On the other end, experimental research could be done to see how fun actually influence desired outcomes. These are of crucial importance for SG. Other possibilities for future work include: testing, developing and detailed analysis of the fun framework, and; expanding the research to digital games as a whole, not just serious games.

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References

Adams, E. (2010) *Fundementals of Game Design*. 2nd ed, *Pearson Prentice Hall*. 2nd ed. Berkeley, CA: New Riders. Available at: http://wps.prenhall.com/bp_gamedev_1/54/14053/3597646.cw/index.html.

Adams, E. (2013) *Fundamentals of Game Design Third Edition*, *New Riders*.

Albuquerque, R. M. de and Fialho, F. A. P. (2010) "Diversão nos jogos eletrônicos : reflexões epistemológicas para o Game Design," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 25–33. (In Portuguese)

Alves, A. G. and Borges, T. L. (2015) "Criança co-criadora de jogos digitais: um estudo de caso com aplicação da abordagem do Design Participativo," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 396–403. (In Portuguese)

Alves, A. G. and Santos, R. A. (2013) "Adequação de jogabilidade para crianças Um estudo de caso com o jogo Rabbit in Danger," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 285–293. (In Portuguese)

Barbosa, S. D. J. *et al.* (2021) *Interação Humano-Computador e Experiência do Usuário*. 1st ed. Edited by S. D. Junqueira and Barbosa. Rio de Janeiro: Autopublicação. (In Portuguese)

Blythe, M. A. *et al.* (2004) *Funology From Usability to Enjoyment*. 3rd ed, *Human-Computer Interaction*. 3rd ed. Edited by Springer. New York, Boston, Dordrecht, London, Moscow: Kluwer Academic Publishers.

Bonnet, L., Lotte, F. and Lécuyer, A. (2013) "Two brains, one game: Design and evaluation of a multiuser bci video game based on motor imagery," *Computational Intelligence and AI in Games*, 5(2), pp. 185–198. doi: 10.1109/TCIAIG.2012.2237173.

Borges, J. B. *et al.* (2020) "Player Experience Evaluation: Which instrument should I use?," *Journal on Interactive Systems*, 11(1), pp. 74–91. doi: 10.5753/jis.2020.765.

Bragg, D. *et al.* (2021) "ASL Sea Battle: Gamifying Sign Language Data Collection," in *CHI Conference on Human Factors in Computing Systems*. ACM, pp. 1–13. doi: 10.1145/3411764.3445416.

Brito, L. F. De *et al.* (2019) "Desenvolvimento e Avaliação do Nutrikids: Um Jogo Educacional Sobre Conhecimento Nutricional e Prevenção da Obesidade," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 918–926. (In Portuguese)

Buchinger, D., Cavalcanti, G. A. de S. and Hounsell, M. da S. (2014) "Mecanismos de busca acadêmica: uma análise quantitativa," in *Revista Brasileira de Computação Aplicada*. doi: 10.5335/rbca.2014.3452.

Cardozo, L. T. *et al.* (2020) "Quebra-Cabeça do Ciclo Cardíaco – Desenvolvimento de uma versão digital online para o ensino de fisiologia cardíaca," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, 1, pp. 997–1004. (In Portuguese)

Cardozo, L. T. *et al.* (2021) "Cardiac Cycle Puzzle: Development and Analysis of Students' Perception of an Online Digital Version for Teaching Cardiac Physiology," *Journal on Interactive Systems*, 12(1), pp. 21–34. doi: 10.5753/jis.2021.1879.

Carneiro, N. *et al.* (2018) "Net.Aura: Design e Aplicação de um Jogo de Realidade Aumentada no Ensino de Redes de Computadores," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 1173–1182. (In Portuguese)

Carvalho, R. N. S. De and Ishitani, L. (2012) "Motivational Factors for Mobile Serious Games for Elderly Users," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 19–28.

Clemes, A. V. *et al.* (2018) "Avaliação de um jogo educativo sobre hábitos alimentares saudáveis e higiene bucal," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, p. 9. (In Portuguese)

Csikszentmihalyi, M. (1991) *Flow: The Psychology of Optimal Experience*. 1st ed, *Academy of Management Review*. 1st ed. New York: Harper Collins. doi: 10.2307/258925.

Cuperschmid, A. R. M. and Hildebrand, H. R. (2013) "Avaliação heurística de jogabilidade Counter-Strike:

Global Offensive," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 371–378.

Dörner, R. *et al.* (2016) *Serious Games, Games Foundations, Concepts and Practice*. Edited by R. Dörner et al. Cham: Springer International Publishing. doi: 10.1007/978-3-319-40612-1.

Doucet, L. and Srinivasany, V. (2010) "Designing entertaining educational games using procedural rhetoric: A case study," *Sandbox: 5th ACM SIGGRAPH Symposium on Video Games*, 1(212), pp. 5–10. doi: 10.1145/1836135.1836136.

Editora Melhoramentos (2021) "Diversão | Michaelis On-line," *Editora Melhoramentos*. Available at: https://michaelis.uol.com.br/moderno-portugues/busca/portugues-brasileiro/diversao. (In Portuguese)

Franzwa, C., Tang, Y. and Johnson, A. (2013) "Serious game design: Motivating students through a balance of fun and learning," *International Conference on Games and Virtual Worlds for Serious Applications, VS-GAMES*. doi: 10.1109/VS-GAMES.2013.6624239.

Freitas, D. Q. *et al.* (2012) "Development and Evaluation of a Kinect Based Motor Rehabilitation Game," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, 2012, pp. 144–153.

Froschauer, J. *et al.* (2010) "Design and evaluation of a serious game for immersive cultural training," *16th International Conference on Virtual Systems and Multimedia, VSMM 2010*, pp. 253–260. doi: 10.1109/VSMM.2010.5665978.

Garry, M. H. *et al.* (2019) "Design and Implementation Serious Game 'Tic Tac Toe Math,'" *International Conference on Computer Engineering, Network, and Intelligent Multimedia, CENIM*, 2019-Novem. doi: 10.1109/CENIM48368.2019.8973336.

Huizinga, J. (2000) *Homo Ludens*. 4th ed. São Paulo: Editora Perspectiva S.A.

Hunicke, R., Leblanc, M. and Zubek, R. (2004) "MDA: A formal approach to game design and game research," *AAAI Workshop - Technical Report*, WS-04-04(August), pp. 1–5.

Iacovides, I. and Cox, A. L. (2015) "Moving beyond fun: Evaluating serious experience in digital game," *Conference on Human Factors in Computing Systems*, 2015-April, pp. 2245–2254. doi: 10.1145/2702123.2702204.

Ihsan, Z., Herumurti, D. and Yunanto, A. A. (2020) "Combination of learning and fun aspect for educational game using gameplay-grafting method," *International Seminar on Application for Technology of Information and Communication: IT Challenges for Sustainability, Scalability, and Security in the Age of Digital Disruption, iSemantic*, pp. 1–6. doi: 10.1109/iSemantic50169.2020.9234246.

Ijsselsteijn, W. A., Kort, Y. A. W. D. and Poels, K. (2013) "The Game Experience Questionnaire. Eindhoven," *Johnson, M.J., VanderLoos, H.F.M., Burgar, C.G., Shor, P., Leifer, L.J.*, 2005(2013), pp. 1–47. Available at: https://research.tue.nl/en/publications/the-game-experience-questionnaire.

Jesus, A. M. De and Silveira, I. F. (2019) "A collaborative game-based learning framework to improve computational thinking skills," *International Conference on Virtual Reality and Visualization, ICVRV*, pp. 161–166. doi: 10.1109/ICVRV47840.2019.00038.

Jhones, E. *et al.* (2021) "Procedural Generation of Isometric Racetracks Using Chain Code for Racing Games," *Simpósio Brasileiro de Jogos e Entretenimento Digital*.

Joselli, M. *et al.* (2014) "Mindninja: Concept, Development and Evaluation of a Mind Action Game Based on EEGs," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, 2014-Decem(December), pp. 123–132. doi: 10.1109/SBGAMES.2014.14.

Jovanovic, M. *et al.* (2011) "Motivation and multimodal interaction in model-driven educational game design," *IEEE Transactions on Systems, Man, and Cybernetics Part A:Systems and Humans*, 41(4), pp. 817–824. doi: 10.1109/TSMCA.2011.2132711.

Karácsony, T. *et al.* (2019) "Brain computer interface for neuro-rehabilitation with deep learning classification and virtual reality feedback," *ACM International Conference Proceeding Series*. doi: 10.1145/3311823.3311864.

Ketcheson, M., Ye, Z. and Graham, T. C. N. (2015) "Designing for exertion: How heart-rate power-ups increase physical activity in exergames," *Annual Symposium on Computer-Human Interaction in Play*, pp. 79–90. doi: 10.1145/2793107.2793122.

Kitchenham, B. and Charters, S. (2007) "Guidelines for performing Systematic Literature Reviews in Software Engineering."

Kolthoff, T., Spil, T. A. M. and Nguyen, H. (2019) "The adoption of a serious game to foster interaction between the elderly and the youth," *IEEE 7th International Conference on Serious Games and Applications for Health, SeGAH*. doi: 10.1109/SeGAH.2019.8882443.

Koster, R. (2013) *Theory of Fun for Game Design*. Sebastopol,: O'Reilly Media, Inc.

Krause, K. K. G. *et al.* (2017) "Jogo Sério para Auxílio no Desenvolvimento do Conceito Multiplicativo," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 236–237. (In Portuguese)

Van de Laar, B., Gürkök, H., *et al.* (2013) "Experiencing BCI control in a popular computer game," *Transactions on Computational Intelligence and AI in Games*, 5(2), pp. 176–184. doi: 10.1109/TCIAIG.2013.2253778.

Van de Laar, B., Bos, D. P. O., *et al.* (2013) "How much control is enough? Influence of unreliable input on user experience," *Transactions on Cybernetics*, 43(6), pp. 1584–1592. doi: 10.1109/TCYB.2013.2282279.

Lam, A. T. *et al.* (2020) "Pac-Euglena: A Living Cellular Pac-Man Meets Virtual Ghosts," *Conference on Human Factors in Computing Systems*, pp. 1–13. doi: 10.1145/3313831.3376378.

Lazzaro, N. (2004) "Why We Play Games: Four Keys to More Emotion Without Story," *Game Dev Conf*, p. 8.

Leite, P. da S. and Almeida, L. D. A. (2017) "Modelo Artefato-Experiência para Elementos dos Jogos e Gameplay," pp. 125–134. (In Portuguese)

Lindberg, R., Seo, J. and Laine, T. H. (2016) "Enhancing Physical Education with Exergames and Wearable Technology," *IEEE Transactions on Learning Technologies*, 9(4), pp. 328–341. doi: 10.1109/TLT.2016.2556671.

Lorenzi, F., Ribeiro, V. V. and Kurtz, G. B. (2018) "RPG Educacional para o ensino de Design Thinking," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 1239–1248.

Machado, R. da S. (2014) "Fator diversão na produção de um jogo eletrônico educativo," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 550–559. (In Portuguese)

Majid, M. S. H. *et al.* (2018) "Performance evaluation of a VR-based arm rehabilitation using movement sequence pattern," *14th International Colloquium on Signal Processing and its Application, CSPA 2018*, (March), pp. 123–128. doi: 10.1109/CSPA.2018.8368698.

Mandryk, R. L. and Atkins, M. S. (2007) "A fuzzy physiological approach for continuously modeling emotion during interaction with play technologies," *International Journal of Human Computer Studies*, 65(4), pp. 329–347. doi: 10.1016/j.ijhcs.2006.11.011.

Maqsood, S., Mekhail, C. and Chiasson, S. (2018) "A day in the life of Jos: A web-based game to increase children's digital literacy," *ACM Conference on Interaction Design and Children*, pp. 241–252. doi: 10.1145/3202185.3202753.

Marques, B. R. C., Levitt, S. P. and Nixon, K. J. (2012) "Software visualisation through video games," in *Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference on - SAICSIT '12*. New York, New York, USA: ACM Press, p. 206. doi: 10.1145/2389836.2389861.

Marsh, T. *et al.* (2011) "Fun and learning: The power of narrative," *6th International Conference on the Foundations of Digital Games, FDG*, pp. 23–29. doi: 10.1145/2159365.2159369.

Marsh, T. (2011) "Serious games continuum: Between games for purpose and experiential environments for purpose," *Entertainment Computing*, 2(2), pp. 61–68. doi: https://doi.org/10.1016/j.entcom.2010.12.004.

McCall, R., O'Neil, S. and Carroll, F. (2004) "Measuring presence in virtual environments," in *Conference on Human factors and computing systems - CHI '04*. New York, New York, USA: ACM Press, p. 783. doi: 10.1145/985921.985934.

Medeiros, R. J. V. De and Medeiros, T. F. V. De (2014) "Procedural Level Balancing in Runner Games," in *2014 Brazilian Symposium on Computer Games and Digital Entertainment*. IEEE, pp. 109–114. doi: 10.1109/SBGAMES.2014.30.

Menezes, J. and Schlemmer, E. (2014) "Desenvolvendo a competência comunicativa através de Social Games nas aulas de Língua Inglesa," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 543–549. (In Portuguese)

Michael, D. R. and Chen, S. L. (2005) *Serious games: Games that educate, train, and inform*. Bostom, MA: Cengage Learning.

Moosa, A. M. *et al.* (2020) "Designing a Mobile Serious Game for Raising Awareness of Diabetic Children," *IEEE Access*, 8, pp. 222876–222889. doi: 10.1109/ACCESS.2020.3043840.

Moser, C., Fuchsberger, V. and Tscheligi, M. (2012) "Rapid assessment of game experiences in public settings," *ACM International Conference Proceeding Series*, pp. 73–82. doi: 10.1145/2367616.2367625.

Nascimento, L. (2020) "Projeto Treinamento: Desenvolvendo Duelos de Memória em uma Proposta de Card Game Engajado para o Treinamento da Capacidade de Concentração," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 987–996. (In Portuguese)

Normal, M. J., MdNor, K. and Ishak, B. I. (2014) "Fun beliefs in digital games from the perspective of human nature: A systematic review," in *International Symposium on Technology Management and Emerging Technologies*. IEEE, pp. 359–364. doi: 10.1109/ISTMET.2014.6936534.

Oliveira, M. J. *et al.* (2019) "Do Not Puzzle the Puzzle Player: When Communicability Issues Influence Playability," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, 2018-Novem, pp. 81–87. doi: 10.1109/SBGAMES.2018.00019.

Ooi, Y. P. *et al.* (2016) "Understanding player perceptions of RegnaTales, a mobile game for teaching social problem solving skills," *ACM Symposium on Applied Computing*, 04-08-Apri, pp. 167–172. doi: 10.1145/2851613.2851678.

Ouherrou, N. *et al.* (2012) "A Heuristic Evaluation of an Educational Game for Children with Dyslexia," *Monatsschrift Kinderheilkunde*, (September), pp. 1229–1235.

Pereira, L. T., Viana, B. M. F. and Toledo, C. F. M. (2021) "Procedural Enemy Generation through Parallel Evolutionary Algorithm," *Simpósio Brasileiro de Jogos e Entretenimento Digital*.

Petersen, K., Vakkalanka, S. and Kuzniarz, L. (2015) "Guidelines for conducting systematic mapping studies in software engineering: An update," *Information and Software Technology*, 64, pp. 1–18. doi: 10.1016/j.infsof.2015.03.007.

Petri, G. and von Wangenheim, C. G. (2016) "How to evaluate educational games: A systematic literature review," *Journal of Universal Computer Science*, 22(7), pp. 992–1021.

Petri, G., von Wangenheim, C. G. and Borgatto, A. F. (2017) "Quality of Games for Teaching Software Engineering: An Analysis of Empirical Evidences of Digital and Non-Digital Games," in *International Conference on Software Engineering: Software Engineering Education and Training Track (ICSE-SEET)*. IEEE, pp. 150–159. doi: 10.1109/ICSE-SEET.2017.18.

Petri, G., Wangenheim, C. G. Von and Borgatto, A. F. (2019) "MEEGA+: Um Modelo para a Avaliação de Jogos Educacionais para o ensino de Computação," *Revista Brasileira de Informática na Educação*, 27(03), pp. 52–81. (In Portuguese)

Petry, S. (2010) "Pode a filosofia auxiliar na compreensão do que é Game ?," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 175–186. (In Portuguese)

Prensky, M. (2001) "Fun , Play and Games : What Makes Games Engaging," in *Digital Game-Based Learning*, pp. 1–31. Available at: http://www.autzones.com/din6000/textes/semaine13/Prensky(2001).pdf.

Rachevsky, D. C., de Souza, V. C. and Nedel, L. (2018) "Visualization and interaction in immersive virtual reality

games: A user evaluation study," *20th Symposium on Virtual and Augmented Reality, SVR*, (2014), pp. 89–98. doi: 10.1109/SVR.2018.00024.

Read, J. C. and MacFarlane, S. (2006) "Using the fun toolkit and other survey methods to gather opinions in Child Computer Interaction," *Conference on Interaction Design and Children, IDC '06*, 2006, pp. 81–88. doi: 10.1145/1139073.1139096.

Rodrigues, L., Bonidia, R. and Brancher, J. (2020) "Procedural versus human level generation: Two sides of the same coin?," *International Journal of Human-Computer Studies*, 141, p. 102465. doi: https://doi.org/10.1016/j.ijhcs.2020.102465.

Satria, F. *et al.* (2017) "EFL learning media for early childhood through speech recognition application," *International Conference on Science in Information Technology: Theory and Application of IT for Education, Industry and Society in Big Data Era, ICSITech*, 2018-Janua, pp. 568–572. doi: 10.1109/ICSITech.2017.8257177.

Schell, J. (2010) *A arte de Game Design*. 1st ed. Elsevier Editora LTDA.

Schroeder, R. B. and Hounsell, M. da S. (2016) "SEU-Q -Um Instrumento de Avaliação de Utilidade de Jogos Sérios Ativos," in *I Simpósio Latino-Americano de Jogos*, pp. 136–145. (In Portuguese)

Shen, C., Wang, H. and Ritterfeld, U. (2009) "Serious games and seriously fun games: Can they be one and the same?," *Serious Games: Mechanisms and Effects*, (September), pp. 48–61. doi: 10.4324/9780203891650.

Silva Bastos, A. *et al.* (2018) "Synesthesia: A Study on Immersive Features of Electronic Games," *Journal on Interactive Systems*, 9(2), p. 1. doi: 10.5753/jis.2018.700.

Silva, E. *et al.* (2018) "An interaction mechanism for virtual reality based on upper limbs motions tracking using depth cameras and inertial sensors," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, 2017-Novem, pp. 46–55. doi: 10.1109/SBGames.2017.00014.

Sobrinho, M. E. *et al.* (2016) "Game Serra Pelada: Projeto Implementação e Avaliação de um Jogo Educativo para o ensino de Geometria para Alunos do 9 do Ensino Fundamental," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 865–872. (In Portuguese)

Souza, V. *et al.* (2019) "Development and Evaluation of a Immersive Serious Game to Support Neuroanatomy Teaching and Learning," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, pp. 927–935.

Su, J. M. and Wu, K. M. (2014) "League of learners (LoL) - A collaborative subject-free learning game scheme to leverage fun and meaningful learning: A study on potential and effect," *International Conference of Educational Innovation Through Technology*, pp. 68–74. doi: 10.1109/EITT.2014.19.

Sweetser, P. and Wyeth, P. (2005) "GameFlow: a model for evaluating player enjoyment in games," *Computers in Entertainment*, 3(3), p. 3. doi: 10.1145/1077246.1077253.

Tondorf, D. F. and Hounsell, M. da S. (2021) "De volta ao parquinho : A busca da diversão no jogo digital," in *GranDGamesBR: Fórum dos Grandes Desafios de Pesquisa em Jogos e Entretenimento Digital no Brasil*. Porto Alegre: Sociedade Brasileira de Computação, pp. 927–930. (In Portuguese)

Torok, L. *et al.* (2014) "AdaptControl: An adaptive mobile touch control for games," *SIGGRAPH Asia Mobile Graphics and Interactive Applications, SA*, pp. 137–145. doi: 10.1145/2669062.2669081.

Umbelino, M. A. M. and Mota, R. R. da (2021) "Negativity in Play - How Negative Emotions create Meaningful Games," in *Anais Estendidos do XX Simpósio Brasileiro de Jogos e Entretenimento Digital (SBGames Estendido 2021)*. Sociedade Brasileira de Computação, pp. 152–161. doi: 10.5753/sbgames_estendido.2021.19635.

Venter, M. and De Wet, L. (2016) "Continuance use intention of primary school learners towards mobile mathematical applications," *Frontiers in Education Conference, FIE*, 2016-Novem. doi: 10.1109/FIE.2016.7757539.

Wang, H., Shen, C. and Ritterfeld, U. (2009) "Enjoyment of digital games: What makes them 'seriously' fun?," *Serious Games: Mechanisms and Effects*, pp. 25–47. doi: 10.4324/9780203891650.

Warriar, V. R., Woodward, J. R. and Tokarchuk, L. (2019) "Modelling player preferences in AR mobile games," *IEEE Conference on Computatonal Intelligence and Games, CIG*, 2019-Augus. doi: 10.1109/CIG.2019.8848082.

Yanti, P. P., Rosmansyah, Y. and Dabarsyah, B. (2019) "Serious Games for Children: A Systematic Literature Review," *1st International Conference on Informatics, Multimedia, Cyber and Information System, ICIMCIS*, pp. 79–84. doi: 10.1109/ICIMCIS48181.2019.8985230.

Zamith, M. *et al.* (2020) "Applying hidden Markov model for dynamic game balancing," *Simpósio Brasileiro de Jogos e Entretenimento Digital*, 2020-Novem, pp. 38–46. doi: 10.1109/SBGames51465.2020.00016.

Zyda, M. (2005) "From visual simulation to virtual reality to games," *Computer*, 38(9), pp. 25–32. doi: 10.1109/MC.2005.297.