







Effectiveness and Fun Metrics in a Pervasive Game Experience: A Systematic Literature Review

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Abstract. The progress of video games, hand in hand with the technological development, has been exponential in recent years. Its diffusion in society through multiple existing formats (computer, console, mobile devices, etc.) is growing. The number of video game players increases every year. As a result, the technical and user experience requirements also increase, and the behavior of the players with the game experience is unknown. Therefore, it is necessary to have the elements that allow evaluating and measuring this behavior from several perspectives. Therefore, it is necessary to have elements that allow evaluating and measuring the behavior of players with the game experience from different perspectives. It is important to have these different points of view to continuing the contribution in this aspect. Having that in mind, it has been made an analysis of measurement of effectiveness' measure and entertainment that will serve as a basis to approach studies in search of improvements in the user experience, a topic of great interest among the current generators or manufacturers of these video games.

Keywords: Effectiveness · Fun · User experience · Game experience · Metrics

1 Introduction

The emergence of new platforms and genres of video games shows us a problem from two perspectives: the analysis of the user experience is approached? And the second, how can we measure the properties that identify the level of “effectiveness” and “fun” of a gaming experience? [1, 2]. In addition, it is necessary to know which elements

within a video game are more related to the development and that can improve the game experience [3].

The general objective of developing a videogame is to be pleasant and rewarding for all possible players, but its design and development is a long and demanding process as well as complex considering the diversity of possible players, but over time it has been oriented to different efforts to design and evaluate usability aspects of videogames in the design and evaluation of usability aspects of these.

On the other hand, the user experience is considered a fundamental part in the evaluation of the video game performance with the user. This should start from the design of the game experiences, using evaluation techniques and repetitive adjustments in such a way that the development of complex processes and costs have greater acceptability in the user [4, 5]. For example, applying gamification patterns that help strengthen the relationship among the game experience and satisfaction [6].

In the videogame industry, effectiveness and entertainment is a subject treated by different authors [7, 8]. Although it lacks of analytical procedures and metrics to obtain a better estimate in the degree of acceptability and appropriation of the game by the player [2]. In this sense, pervasive games want the user to use and see the world in a different way, using the elements that are already integrated in our lives and that are part of the game.

The gaming experiences that have a higher level of gamification generate greater motivation and have greater acceptance by users as identified by Garcia in 2009 [4]. For this reason, there is a need in the video game industry to develop research that generates techniques and tools that allow the objective evaluation of the player's experience in games [9]. This article uses a thematic analysis of research for the classification of articles that have been published since 2009 to the present. These articles were searched in four databases: Scopus, IEEExplorer, ACM and Springer.

This article is structured as follows: Sect. 2 provides definitions and related works. In Sect. 3 we show the used methodology to carry out the systematic review of the literature. Section 4 shows the obtained results during the extraction and analysis of data. Finally, Sect. 5 describes the conclusions and future work.

2 Background

Metrics have been an important part since the beginning of software development [10], but as expressed in the literature, the measurement of user experience in video games is different due to the special characteristics of this type of software [11]. For a better understanding of this document, where was considered the works carried out and published that relate to the purpose of this review and the most important terms to be used are defined as effectiveness, metrics, and entertainment; as well, a review and detailed description of the theories that support the investigation.

2.1 Pervasive Games

According to [12], The Pervasive games (PG) are the kind of games that have the greatest complexity due to the diversity of characteristics and evolution of their rules and dynamics. From the perspective of user experience, a PG offers the player an enriched game experience through an evolution of the game dynamics, expanding the game space according to the context where it is played. This allows breaking the boundaries of the game world, making reality part of it and that the elements in that reality have an influence during the game [11].

The growing presence of games that combine the real world and the virtual world (game world) has the objective of improving the user experience. These are based on new technologies, context and multiple media with the existence of a narrative focused on the use of the interaction with the game for the appropriation of knowledge. Thus, there is evidence of the need to have a broad study about the possible metrics to be used in the evaluation of a game (whether or not it is pervasive). Everything, with the aim of improving the user experience that the player has with the gaming experience.

2.2 Game Metrics

Game metrics are interpretable measures of something related to games. Specifically, they are quantitative measurements of the attributes of the objects. A common source of game metrics is the telemetry data of the player's behavior [12, 13]. According to [14], there are three types of indicators used by game user experience researchers: (1) user metrics (related to the player), (2) performance metrics (related to software or hardware) and (3) process metrics (related to developing the game). When the game is measured, aspects of the game must be included, but there is something more important, the player's experience. In this line, there are metrics known as "playability metrics" [15] that allow measuring the fun of the player.

2.3 Effectiveness

A definition of effectiveness given by the famous video game designer Sid Meier, would be "the degree in which an interface facilitates the user to fulfill the task for which it was designed". This usually refers to the degree in which errors are avoided and tasks are successful, measured by "success rate" or "completion rate of tasks". By contrast, a measure of "error rate" is the amount of errors committed, and when are used to guide the design, those errors are often classified by cause [16].

2.4 Fun

Fun is recreation, rest, entertainment, hobby, joy, etc. The words "to have fun" have the meanings of entertaining, recreating and also those of diverting, distancing, and separating from routine. In military art, a secondary enterprise is called diversion which is carried out far from the main area of operations in order to get the attention of the enemy and separate it from its main objective, or force it to distract forces from the bulk of its army, weakening it. Historically, each era has had different ways of having fun [17].

3 Systematic Review of Literature

A systematic review of the literature is a method to analyze, evaluate and interpret each study relevant to a particular research question, specific area or phenomenon of interest [1]. This process was originated in the medical science due to the increasing amount of research in each area [18]. Consequently, it was necessary to identify and guide the research towards an uninvestigated subject [19]. The scientific community has proposed some steps for the application of these protocols, more specifically in the area of software engineering.

Kitchenham and Charters [18] propose a series of steps that are used in this document, which are adapted to our needs. The process of this methodology is presented in the following sections. The main objective of this systematic review of the literature was to obtain important data on scientific production considering the approach by academics and researchers in journal documents and/or conference proceedings, in order to identify the current state of effectiveness and fun metrics in video games. For this purpose, it was planned to search the different databases for relevant articles and we consider that the following questions are important for the investigation:

- **RQ1:** How to measure effectiveness and fun for the evaluation of a gaming experience?
- **RQ2:** Are there metrics that consider the characteristics of pervasive games in terms of effectiveness and fun?

3.1 Search Terms

It was necessary to evaluate different topics to select the terms to use in the search chains and their synonyms. In the case of pervasive games, the word pervasiveness was removed because many metrics applied to traditional games can apply in pervasive games. The terms to take into account in the systematic review are:

Mandatory words:

1. Metrics
2. Effectiveness
3. Fun
4. Gameplay

Optional words:

1. Gamification
2. Video games

3.2 Search Strategy

Considering the terms of Sect. 3.1, we have built a query string and this is complemented by logical operators to improve the execution results. We limited the search process to documents that had been published in journals, conference proceedings or book chapters since 2009. The sequence was executed on August 12th, 2018. For each database, it was necessary to build a specific query because each one has a different syntax; an example of a resulting query is shown below.

*acmdlTitle:(+gameplay metrics measure) OR (+gameplay effectiv fun) AND
recordAbstract:(+gameplay metrics measure) OR (+gameplay effectiv fun) AND
keywords.author.keyword:(+game* effectiv* fun) AND (+game* metrics* measure)*

3.3 Exclusion Criteria

1. Articles discarded by name.
2. Articles discarded by the summary.
3. Articles discarded by full text.

3.4 Inclusion Criteria

1. Articles included in the databases of Table 1.
2. Articles Published in Spanish and English.
3. Articles as a result of conferences, congresses, journals, book chapters.
4. Articles published since 2009.

3.5 Collected Information

We consider different databases to execute the search strings. Access to databases is private; the databases are shown in Table 1.

Table 1. Databases used in the search

Name	Acronym	URL
ACM digital library	ACM	https://dl.acm.org/advsearch.cfm
IEEE Xplore digital library	IEEEExplore	http://ieeexplore.ieee.org/
Springer link	Springer	https://link.springer.com
Scopus preview	Scopus	https://www.scopus.com/

When executing query strings in the databases of Table 1, 960 documents were found, which are in Appendix A; the results are shown in Table 2.

Table 2. Results of the run query for each database

Data base	Results	%
ACM	441	46
IEEEExplore	14	2
Springer	386	40
Scopus	119	12
	Total 960	

4 Data Analysis and Results

Table 2 shows the general results of the search. It was analyzed and evaluated the title and the abstract for each paper. Table 3 shows the percentages for the results of analysis.

Table 3. Title, abstract and full-text analysis results in the databases

Database	Total	D ^a	%D	A ^b	%A	TR ^c	AR ^d	RFT ^e	R ^f	%R
ACM	441	1	0,2	4	0,91	426	8	3	437	99
IEEEExplore	14	0	0	0	0	9	5	0	14	100
Springer	386	0	0	2	0,5	366	12	6	384	99,5
Scopus	119	0	0,0	0	0	101	15	3	119	100
Total	960	1	0,1	6	0,6	902	40	12	954	99,4

^aDuplicate: When a document was included in the results list more than once

^bAccepted: Document that meets the requirements of the exclusion/inclusion criteria

^cRejected by title: Documents excluded because the title indicates another area of study

^dRejected for Summary: Documents excluded because the summary indicated another area of study

^eRejected by full text: documents excluded because the content indicated another area of study

^fRejected: Documents that do not meet the exclusion/inclusion criteria requirements (sum of TR, AR, and FTR)

4.1 Process Description

Once the first exclusion criterion was applied (based on the title), the number was reduced from 960 to 58 documents. When applying the second exclusion criterion (based on the abstract), the number of articles was reduced to 18. These 18 documents were read to achieve the third exclusion criterion (based on the full text). Finally, 6 documents were selected to answer the research questions.

Then, the referenced papers in Appendix A were classified by the categories. These categories as shown in Table 4, which were supported by data from: [18–22].

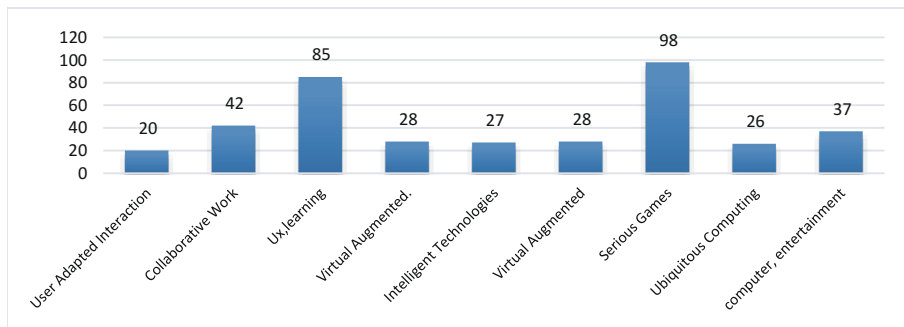
Figure 1 shows the results of the classification of the articles. The subcategory of serious games has 98 related documents, followed by the subcategory of Ux-Learning.

4.2 Results

After performing all the analysis of the data and the description of the process carried out, the effectiveness and fun metrics found in the accepted articles were shown, these metrics were classified in the categories of Social Game Metric, Measuring Player Population, Online Advertising [23, 26] as well as all the papers that were found in the different databases, a number was assigned to each one (Table 5).

Table 4. Results according to paper category

Category	Subcategory	#	Studies
Academic	User Adapted Interaction	20	576, 891, 894, 664, 941, 811, 719, 819, 914, 642, 917, 847, 924, 583, 613, 730, 840, 748, 865, 892
	Collaborative Work	42	632, 783, 835, 836, 852, 928, 648, 620, 929, 930, 937, 734, 787, 922, 886, 944, 896, 863, 712, 919, 678, 791, 867, 720, 765, 885, 568, 831, 722, 689, 687, 729...
	Ux, learning	85	561, 562, 563, 567, 569, 570, 581, 584, 599, 604, 618, 636, 679, 707, 746, 843, 753, 574, 585, 606, 644, 681, 762, 845, 846...
Technological	Virtual Augmented	28	890, 564, 598, 652, 704, 805, 866, 923, 789, 717, 731, 793, 936, 875, 830, 875, 895, 724, 572, 603, 695, 901, 688, 898, 698, 738, 860, 940
	Intelligent Technologies	98	927, 737, 743, 760, 617, 673, 690, 699, 700, 775, 818, 862, 908, 932, 596, 609, 623, 624, 643, 658, 676, 795, 799, 832, 909, 591, 747, 751, 755, 759, 767, 792, 826, 858, 861, 921, 942, 586, 701, 814, 694, 639, 739, 822, 841, 655, 876, 571, 638, 668, 692...
	Ubiquitous Computing	26	580, 595, 645, 761, 802, 887, 889, 905, 915, 801, 602, 742, 807, 873, 630, 674, 682, 800, 812, 960, 565, 589, 650, 653, 659, 735
Entertainment	Computer, entertainment	37	573, 577, 579, 587, 601, 605, 625, 660, 66, 777, 696, 709, 711, 721, 768, 773, 804, 810, 815, 849, 900, 903, 904, 906, 938, 813, 611, 641, 662, 786...

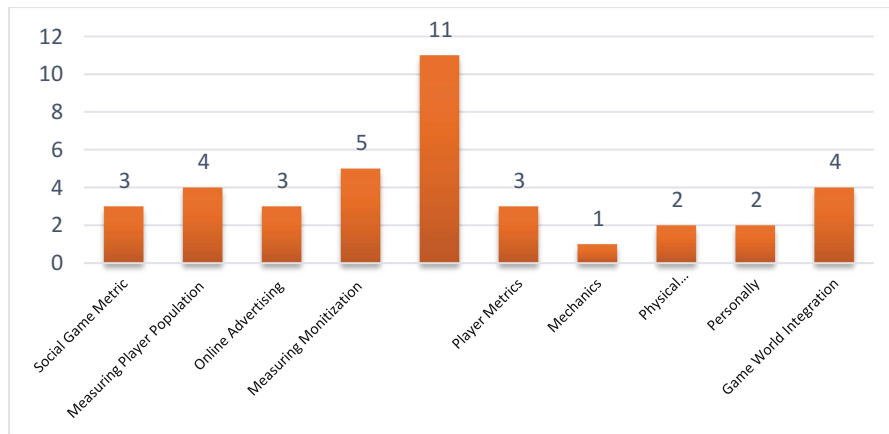
**Fig. 1.** Amount of papers classified by category

The information in Table 5 will be better interpreted in Fig. 2, which shows the number of metrics per category.

In Fig. 2 we can see that in the category Strong Narrative Structure, Meaningful Story Pieces, Interactivity, Skill Level is where there are more metrics found, then, according to the data thrown in the systematic review, the category of measuring

Table 5. Classification of metrics.

N° paper accepted	Category	#	Metrics
166	Social Game Metric	3	M001, M002, M003
285	Measuring Player Population	4	M004, M005, M006, M007
	Online Advertising	3	M008, M009, M010
	Measuring Monetization	5	M011, M012, M013, M014, M015
00	Strong Narrative Structure, Meaningful Story Pieces, Interactivity, Skill Level	11	M016, M017, M018, M019, M020, M021, M022, M023, M024, M025, M026
561	Player Metrics	3	M027, M028, M029
604	Mechanics	1	M030
	Physical behavior	2	M031, M032
	Personally	2	M033, M034
	Game World Integration	4	M035, M036, M037, M038

**Fig. 2.** Metrics contributed by the paper

monetization with a total of 5. Based on our systematic review of the literature and its results, provided answers to the research questions:

- **RQ1:** Through the effectiveness and entertainment metrics found in the review of the literature and taking advantage of their classifications, we can have the precision of knowing how effective and funny videogame can be. Furthermore, based on the findings, it can be concluded that the heuristics defined in the user experience can also be useful elements in the process of evaluating the effectiveness and entertainment transmitted by a gaming experience to the player.

- **RQ2:** According to this review, there are few studies on effectiveness and entertainment metrics in pervasive gaming experiences. As shown in Fig. 3, the metrics do not receive enough importance from researchers in this field. However, these metrics are fundamental in generalized computing environments due to limited hardware resources on mobile devices and the user experience that a person may have.

5 Conclusions and Future Work

This article presented a systematic review of the literature, which was aimed at answering research questions related to game effectiveness and fun metrics that could also be applied in a pervasive context. As a main conclusion, we can say that, through the systematic review, few metrics were identified that haunt the effectiveness and fun in pervasive games, with this we realize that there are still many possibilities of study in this area in order to improve the user experience.

On the other hand, we found a lot of study carried out in gaming experiences, but these are not measured through criteria that can be defined as metrics. Which leads us to conclude that these studies have not had the possibility of having tools that support the measurements that in many cases need to obtain better results in terms of the user experience.

It must be proposed efficiency and fun metrics based on the gameplay. And these metrics cover thematic of both general games and pervasive games. It will also be necessary to implement a prototype that serves as an experiment to apply the catalog of the metric set. This prototype will be a pervasive game that supports new students of higher education in the spatial adaptation of buildings, classrooms and main offices of a faculty or university.

Acknowledgments. This work has been funded by the Ministry of Economy and Competitiveness of Spain as part of the DISPERSA project (TIN2015-67149-C3-3-R) and the Excellence Project of the Regional Government of Andalusia (P11-TIC-7486).

Appendix A. Paper Identified

This information is available at <http://goo.gl/QWDFwF>.

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