Decision-making in Game Development Process - A Systematic Review

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***Abstract*—Game development is a field that has been continuously researched. The current state of the art of game development has been applied in many fields, from education to design research. This work has the objective of identifying, evaluating, and interpreting published research that examines how decision-making impacts the game development process. To achieve that, a systematic review of current literature was conducted. In this review, 36 works were identified as primary studies. The studies were then classified according to research focus and the use of game development the authors focused on. The review investigates what it is known about the challenges and opportunities in the use of decision-making in game development. The results show data about game development, gaps in current research and models of successful implementation.**

Keywords*—game development; decision-making; systematic review.

I. Introduction

Before, software products usually were developed to solve a problem or provide a service, whereas games were considered a form of entertainment, with no inherent value or usefulness beyond the scope of providing user experience [1]. Nowadays, the video games industry is worth billions of dollars [3] and the current state of the art of game development has been applied in many fields like education [7][37], design research [22], alleviating anxiety [38] and combating dementia [39].

However, to develop a game is simultaneously an advanced software product and a complex work of creativity and art [2]. This merger of disciplines makes video game production an interesting process to study from many different perspectives, but it also poses several challenges for the game development community.

This work is organized as follows: in Section II, we present a brief discussion about the work theme: basic concepts of game development and decision-making. Section III presents the applied protocol to conduct this review. In Section IV, the results of this review are shown. In Section V, the results are discussed. In Section VI, we conclude this work.

II. Game development and decision-making

Decision-making can affect the software development process at every stage: from requirements analysis, to product delivery, to the consumer. Although a game is a software, its development process has more phases and involves more stakeholders than commercial automation software, for example. Because it has more phases and more stakeholders, therefore, the game development process has more decisions being made all the time.

Several papers cite how these decisions impact the game development process. These works include: user experience [16][23], gameplay [15], monetization models [35], project and code quality [4][11][34], sales [9][21], social media [24] and the gaming industry as a whole [1][13][25].

Seeking to understand how to optimize this decision-making, researchers have been analyzing the game development process using data on: gameplay [15][28][32], artificial intelligence behavior [30], sales [9][21], rates game completion [30], among others.

III. Applied Protocol

Our review methodology is composed of eight steps: (1) development of the protocol, (2) definition of search questions (3) definition of search questions, (4) identification of inclusion and exclusion criteria (5) search for relevant studies, (6) critical assessment, (7) extraction of data, and (8) synthesis. The steps applied to the study contained herein are presented below.

The objective of this review is to identify primary studies that focus on game development process and the use of decision-making. The following question helps identifying primary studies:

- How does decision-making impact the game development?

From this central question, other secondary questions were developed to help in the comprehension of the problem:

- Which tools can be applied to evaluate the accuracy of decision-making in game development?
- What are the opportunities and challenges in adopting of decision-making in game development?

A. Inclusion and Exclusion Criteria

For this review, we considered studies that were published starting from year 2017. The following studies were also excluded:

- Studies not published in the English language;
- Studies that were unavailable online;
- Studies not based on research and that express only the official opinions of governments and field experts;
- Call for works, prefaces, conference annals, handouts, summaries, panels, interviews and news reports.

B. Search Strategies

The databases considered in the study are in the list below:

- ACM Digital Library;
- IEEE Xplore;

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- ScienceDirect – Elsevier.

Combinations of terms were created to guarantee that relevant information would not be excluded when querying different search engines and databases. As a result, three search strings were created:

- String 1: “decision-making” AND “game development”
- String 2: “decision-making” AND “game development” AND (tools OR evaluate)
- String 3: ”game development process”

We noted that to use the complementary string “and decision-making” did not increase the results. In the process of extracting information from the databases, the search strings were used separately in each database. The searches were performed in August 2019.

The results of each search were grouped together, according to database and were, later, examined closer in order to identify duplicity. Tables I - III show the number of studies found in each database, with the string utilized in the search.

TABLE I. NUMBER OF STUDIES FOUND IN EACH DATABASE FOR STRING 1

Database	Number of studies
ACM Digital Library	2
IEEE Xplore	5
ScienceDirect – Elsevier	105

TABLE II. NUMBER OF STUDIES FOUND IN EACH DATABASE FOR STRING 2

Database	NUmber of studies
ACM Digital Library	20
IEEE Xplore	2
ScienceDirect – Elsevier	101

TABLE III. NUMBER OF STUDIES FOUND IN EACH DATABASE FOR STRING 3

Database	Number of studies
ACM Digital Library	8
IEEE Xplore	4
ScienceDirect – Elsevier	33

C. Studies Selection Process

This section describes the selection process from the beginning, namely, from the initial search using the Search Strategies described above to identification of primary studies.

At the first step, 261 works were found with the initial research strings. Duplicated works were removed and, for title analysis, 143 works were selected. After the title analysis, 75 works were selected for abstract analysis. In the end, 36 works were selected based on the abstract analysis for full read. Table IV presents the number of studies filtered in each step of the selection process.

TABLE IV. NUMBER OF STUDIES FILTERED IN EACH STEP OF SELECTION PROCESS

Phase of Selection Process	Number of Studies
1. Databases Search	261
2. Title Analysis	143
3. Abstract Analysis	75
4. Full read	36

D. Quality Assessment

In the quality assessment stage, works passed through a critical analysis. In this stage, the complete studies were read and analyzed, instead of only the titles or abstracts. After this, the last studies that were considered uninteresting for the review were eliminated, resulting in the final set of works.

Six questions were used to help in the quality assessment. Those questions helped determine the relevance, rigor, and credibility of the work being analyzed. The questions were:

- Question 1: Does the study examine how decision-making can improve the game development process?
- Question 2: Does the study present aspects related with challenges or opportunities in adopting decision-making in game development process?
- Question 3: Does the study present tools to evaluate the accuracy of decision-making in game development process?
- Question 4: Is the context of the study adequately described?
- Question 5: Does the study contribute to research in game development and decision-making?
- Question 6: Does the study contribute to research in game development in any way?

Of the 75 studies that were analyzed in the quality assessment stage, 36 passed to the stage of Data Extraction and Synthesis and were thus considered the primary studies. The quality assessment process will be presented in detail in the result section, along with the assessment of the 36 remaining studies.

IV. RESULTS

In this paper, 36 primary studies were identified [1] – [36]. Each one deals with on a wide array of research topics and utilize a wide set of exploration models for each different scenario.

According to the studies above, it was identified that are opportunities to research decision-making in many phases of game development process: user experience [16][23], gameplay [15], monetization models [35], project and code quality [4][11][34], sales [9][21], social media [24], requirements analysis [32] and the gaming industry as a whole [1][13][25].

A. Quantitative Analysis

The research process that was developed resulted in 36 primary studies. As Table V shows, they were written by 130 authors, linked to institutions based in 20 different countries, distributed on five continents, and were published between 2017 and 2019.

In regards to the country of origin, most of the publications came from the United States of America, Netherlands, Canada and Brazil (five publications), followed by Finland

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(four works), Australia (three works), Arab Emirates, Pakistan, Spain, Taiwan and the United Kingdom (two works). Each of the other remaining countries had only one publication.

Figure 1 shows the percentage of participation of each continent in the primary studies. The tag "Global" is for the studies with more than one country or continent involved in the research.

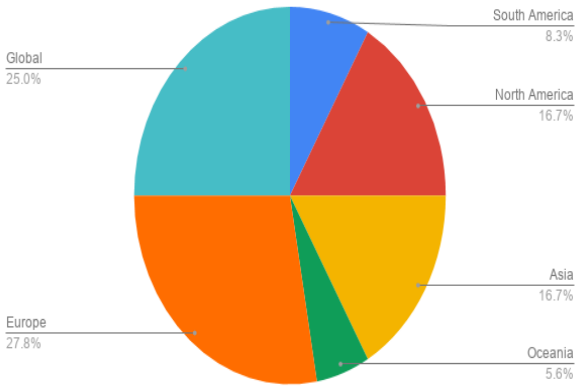

Figure 1. Participation of each continent

The large number of countries that have publications on the subject of game development and decision-making show how widespread the topic is globally.

Table VI shows what type of research was conducted in the primary studies. Figure 2 presents the percentage of each type of research.

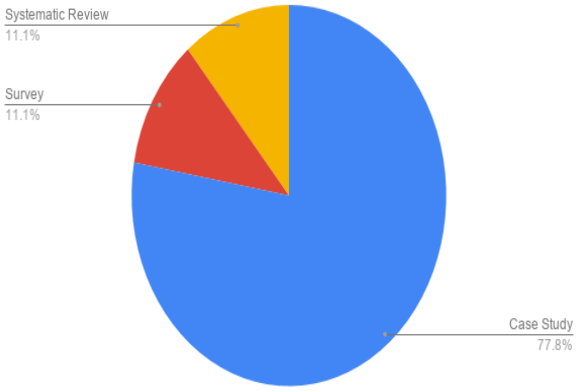

Figure 2. Type of research

B. Quality Analysis

As it was described in section D - Quality Assessment - each of the primary studies was assessed according to six quality criteria that relate to rigor and credibility as well as to relevance. If considered as a whole, these six criteria provide a trustworthiness measure to the conclusions that a particular study can bring to the review. The classification for each of the criteria used a scale of positives and negatives.

TABLE V. COUNTRIES AND NUMBER OF AUTHORS

Study	Country	Authors (number)
[1]	Finland	3
[2]	Sweden	4
[3]	United Arab Emirates	4
[4]	Canada (a), Pakistan (b), United Arab Emirates (c)	4(1a + 1b + 2c)
[5]	Pakistan	3
[6]	United States of America	5
[7]	Brazil	7
[8]	United States of America	1
[9]	Jordan	3
[10]	United States of America	1
[11]	Brazil (a), Canada (b), Egypt (c)	6 (4a+1b+1c)
[12]	Austria (a), United Kingdom (b)	4(3a+1b)
[13]	Netherlands	1
[14]	Brazil (a), Canada (b)	4 (2a+2b)
[15]	Netherlands (a), Canada (b)	3 (1a+2b)
[16]	Brazil	5
[17]	Australia	1
[18]	Australia	4
[19]	Norwegen	2
[20]	Netherlands	4
[21]	Canada	3
[22]	Spain	5
[23]	Spain (a), Netherlands (b)	5 (3a + 2b)
[24]	Finland	4
[25]	United Kingdom (a), Italy (b)	8 (7a + 1b)
[26]	Brazil	3
[27]	Taiwan	3
[28]	United States of America	5
[29]	Japan	2
[30]	India	2
[31]	United States of America	2
[32]	Netherlands	1
[33]	Finland	6
[34]	Taiwan (a), United States of America (b)	3 (2a + 1b)
[35]	Australia (a), Switzerland (b)	6 (5a+ 1b)
[36]	Finland	3
Total		130

Table VII presents the results of the evaluation. Each row represents a primary work and the columns 'Q1' to 'Q6' represent the 6 criteria defined by the questions used on quality assessment: decision-making and game development, challenges and opportunities, tools to evaluate decision-making impacts, context, contribution for decision-making and game development, and contribution for game development in any way, respectively. For each criteria, '1' represents the positive answer and '0' the negative one.

All studies that were analyzed in this step had positive answers for questions 1 and 2 because, as previously stated in the research methodology part, these questions represent inclusion and exclusion criteria. Consequently, all studies with negative answers to at least one of these criteria were already removed during selection stage.

All studies that were analyzed provided information on the context of the work and contributed in some way to research game development. Only 17 of 36 studies answered the question 3 about tools to evaluate accuracy of decision-making in game development. The same fraction, 17 of 36 studies, obtained the maximum score (6) in quality analysis.

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TABLE VI. TYPE OF RESEARCH

Study	Type
[1]	Survey
[2]	Systematic Review
[3]	Systematic Review
[4]	Case Study
[5]	Case Study
[6]	Case Study
[7]	Case Study
[8]	Case Study
[9]	Survey
[10]	Case Study
[11]	Case Study and Survey
[12]	Case Study
[13]	Systematic Review
[14]	Case Study
[15]	Case Study and Survey
[16]	Case Study and Survey
[17]	Systematic Review
[18]	Case Study
[19]	Survey and Interviews
[20]	Case Study
[21]	Case Study
[22]	Systematic Review
[23]	Case Study
[24]	Survey
[25]	Case Study
[26]	Case Study
[27]	Case Study
[28]	Case Study
[29]	Case Study
[30]	Case Study
[31]	Case Study
[32]	Case Study
[33]	Case Study
[34]	Case Study
[35]	Case Study
[36]	Case Study

TABLE VII. QUALITY ANALYSIS OF PRIMARY STUDIES

Study	Q1	Q2	Q3	Q4	Q5	Q6	Total
[1]	1	1	0	1	1	1	5
[2]	1	1	0	1	1	1	5
[3]	1	1	0	1	1	1	5
[4]	1	1	1	1	1	1	6
[5]	1	1	1	1	1	1	6
[6]	1	1	0	1	1	1	5
[7]	1	1	0	1	1	1	5
[8]	1	1	1	1	1	1	6
[9]	1	1	0	1	1	1	5
[10]	1	1	0	1	1	1	5
[11]	1	1	0	1	1	1	5
[12]	1	1	1	1	1	1	6
[13]	1	1	1	1	1	1	6
[14]	1	1	1	1	1	1	6
[15]	1	1	1	1	1	1	6
[16]	1	1	0	1	1	1	5
[17]	1	1	0	1	1	1	5
[18]	1	1	0	1	1	1	5
[19]	1	1	0	1	1	1	5
[20]	1	1	0	1	1	1	5
[21]	1	1	1	1	1	1	6
[22]	1	1	0	1	1	1	5
[23]	1	1	0	1	1	1	5
[24]	1	1	0	1	1	1	5
[25]	1	1	0	1	1	1	5
[26]	1	1	1	1	1	1	6
[27]	1	1	1	1	1	1	6
[28]	1	1	1	1	1	1	6
[29]	1	1	1	1	1	1	6
[30]	1	1	1	1	1	1	6
[31]	1	1	0	1	1	1	5
[32]	1	1	1	1	1	1	6
[33]	1	1	1	1	1	1	6
[34]	1	1	1	1	1	1	6
[35]	1	1	1	1	1	1	6
[36]	1	1	0	1	1	1	5
Total	36	36	17	36	36	36	-

V. DISCUSSION

After the analysis and data extraction steps performed on the primary works, it was possible to identify some aspects related to how decision-making impacts the game development process.

In the first place, it is possible to conclude that decision-making impacts all stages of game development process, from requirements analysis to user experience, consequently affecting game sales and industry survival. All primary works were published after 2017, therefore, this research field is very active.

The systematic review also found it difficult to find open data from the gaming industry, since some databases cited in the articles (SteamDB and SteamSpy [21][29]) are Application Programming Interfaces (API) that do data mining in the Steam store.

In addition to keeping research on game development in vogue, one of the advantages of the present work was to show a well-documented and detailed research process, easy to be replicated and tested.

As a disadvantage in relation to the researched works, we noticed that there is no interaction with the developers as well as the industry can hinder the results. However, we tried to collect data directly from them at the beginning of this work using social networks and other means of contact, which unfortunately, did not result in a relevant amount of data. This fact corroborates the statement about the difficulty of collecting data from the gaming industry.

A. How decision-making is impacting game development?

This review illustrated that decision-making impacts every stage of the game development process, as pros decision-making can provide: improved performance, quality, sales and user experience. The negative impacts are: to affect the artistic spectrum of game development as it may limit the creative process.

B. Which tools can be applied to evaluate the accuracy of decision-making in game development?

In this review, it was noticed the lack of research about the tools that have been applied to evaluate the accuracy of decision-making in game development. Only 17 of 36 studies showed or briefly identified some type of tool. The identified tools are: playtesting data, postmortem documents, Halstead complexity measures; learning performance, conclusion of activities performance, SteamSpy and SteamDB, game telemetry,

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virtual reality, heat analysis, artificial intelligence behavior, requirement analysis, tests analysis, project quality analysis and monetization model analysis.

C. What are the opportunities and challenges in adopting of cloud computing in decision-making tools?

The key decision-making challenge in the game development process is to control the process to meet scope, time, and budget, while not limiting the creative process and user experience. One opportunity found in this review was the lack of work addressing how to improve the game sequence development process using decision-making during this process. Also other opportunities were identified: artificial intelligence, education, serious games, social media, lack of open data about games and to analyze more games.

VI. Conclusion

The main objective of this work was to conduct a search and analysis of the adoption of decision-making to improve the game development process. To that goal, a systematic review was conducted, briefly analyzing 261 papers and deeply analyzing 36 papers in order to discuss topics about the usage of decision-making. During the analysis phase, it was realized that the decision-making has been widely applied in many steps of game development process.

As future works, we intend to conduct further studies related to how game development companies and game developers apply decision-making in game sequels development.

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