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IMPROVING SERIOUS GAME DESIGN THROUGH A DESCRIPTIVE CLASSIFICATION : A COMPARATION OF METHODOLOGIES

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ABSTRACT

Serious game provides an instructional tool to make the learning process more enjoyable, easier to memorize and effective. It combines pedagogy goals and game play to increase the participant interest and engagement compared to traditional methods. In this paper, we compare several methodologies of game design relative to our classification proposal; it can assist the analysis and evaluation of serious game design, we illustrate how this classification helps several actors of design to make more informed decisions about the adequate methodology. Finally, we discuss the differences in the use of serious game design methodologies in the follow-up of the statistics of the comparative study.
Keywords: *Serious Game; Learning; Game Design; Comparative Study.*

1. INTRODUCTION

There are currently a number of studies that highlight games as an enhanced experience to make learning process more efficient compared to traditional teaching methods [1], [2],[3][4][5]. In this direction, several methodologies of game design have been elaborated to help the serious games development [6][7][8][9][10][11][12][13][14][15][16] [17] [18] [19], providing the requirements analysis and interpretations related to connecting the learning purposes to the gaming mechanics. Although some methodologies focus on the low analysis level such as [15][16][17], other methodologies study the relationship between the high level, learning and entertainment, and the low level, game components.

The better integration of the learning objectives, the high level, into the game mechanics, the low level, provides the efficient educational serious game, the resulting coherence of learning process and player engagement. However, the biggest issues of serious games to date is the inadequate integration of learning and game design components[20], as it requires a balance between the entertainment and educational concepts from the design phase, and also a common vocabulary between designers and educational experts. This perspective, shared by all methodologies of serious game design, will be considered in our comparative study.

This paper proposes a comparative study of 14 existing methodologies on serious game design that appeared from 2004 to 2015, introducing a classification between 18 categories and 99 sub-categories. We will survey serious games design, present new classifications regarding their different aspects and analyze each game design methodology based on the functionalities described in the classification. We will provide an analytical dashboard to see if methodologies fill gaps on certain design requirements on serious games such as design evaluation, collaboration, practical tools, and correlation between the pedagogical and entertainment levels. The paper has been structured as follows. Section 2 explains the method and scope of the study. Section 3 details the different methodologies related to serious games design. Then, Section 4 presents the characteristics according to which all surveyed serious games design methodologies will be classified. Section 5 presents in a comparison table a summary of their main characteristics. Section 6

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presents graphs and a discussion of the results. Finally, Section 7 concludes the paper.

METHOD AND SCOPE OF STUDY

All throughout this bibliography, we considered not only the design methodologies for serious games, but also the methodologies of entertainment games with the aim to analyze the integration of both entertaining and pedagogical resources.

To carry out our research, we selected 14 game design methodologies appeared between 2004 and 2015, and published in journals indexed in the following libraries: International online bibliographic databases of Science Direct, Google Scholar, Springer, and British Journal of Educational Technology.

In order to establish our comparative study, we provide a classification that collects the specifications used by the methodologies. They are classified according to their functions.

We have then filled Table1 of results section using the correspondence between our classification and the existing methodologies, allowing us to generate the representative graphs for our discussion and to give a perspective for future research into serious games.

2. RELATED WORK

Game design provides an analysis of the game creation and evaluation goals, rules, and challenges involved to increase the player experience. Several methodologies have been proposed to highlight an effective game design.

The Activity Theory-based Model of Serious Games (ATMSG) [6] involves the activity theory to connect gaming with learning goals and instruction. Each activity describes their actions, tools, and goals. The Hierarchical Activity-Based Scenario (HABS) [7] focuses on the activity theory to measure the player engagement, it help designers to create levels of the user experiences. Consequently, it doesn't provide explicitly the connection between gaming and learning through serious games. The learning mechanics and game mechanics (LM-GM) [8] has been designed to allow different users to describe games according to the pedagogical approaches, it maps the learning mechanics to several game mechanics following the specific serious game under analysis. The Game Object Model (GOM) II [9] is designed to identify concrete (gaming) and abstract (objectives) components on the educational games using the object oriented programing theory.

The Libraries of Commonly Reoccurring Patterns (LCRP)[10] present a taxonomy library to enhance communication between the experts about serious games design, it focuses on the design pattern representation of pedagogical objectives, domain simulation, interaction, problems, decorum, and condition of use. The Game–based Learning Framework [11] focuses on the analysis requirements of serious games following three steps: defining learning, instruction, and assessment. It involves Bloom's taxonomy for learning layer and the four dimensions [12] to highlight instructions. The four dimension (4D) [12] framework defines four dimensions to evaluate games and simulation-based education; it considers pedagogy, mode of representation, context, and learner specifications.

The RETAIN model [13] focuses in defining common game elements, and incorporates Gagné's nine events of instruction and Keller model in order to promote pedagogy content in serious game design. The experiential gaming model (EGM) [14] involves the experiential learning theory and flow theory to design serious games; it matches challenges to skill levels, goals, feedback, control, playability, game fullness, attention and story. The Game Ontology Project (GOP) [15] postulates prototype theory to help the design analysis, it consists on defining five elements: interface, rules, goals, entities and entity manipulation. Djaouti [16] aims to classify video games following the "metabricks" concept; it describes a game on elements and rules including the game objectives.

The mechanics, dynamics, and aesthetics (MDA)[17] divides the relation "Game-Player" in three distinct levels; mechanics aims to analyse the game at the "game rules", dynamics focuses on the system that arises when the player uses the game, and aesthetics is dedicated to the understanding and analysis of the feeling of the player.

The Design, play, and experience (DPE) [18] framework is an approach to design a game for learning, and proposes a collaborative (designer-player) framework to promote reflection and analysis phase on serious game design, it highlights an interactive process (design, play, experience) of analysis related to each layer of design (learning, storytelling, gameplay, user interface).

The DSVL [19] focuses on educational video game development for educators, who do not have programming background, and it employs a multidisciplinary approach based on visual language and narrative theory concepts to create and maintain description of games.

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3. CLASSIFICATION OF SERIOUS GAME DESIGN

Across the literature reviews presented in the related work section, game methodologies highlight a helpful tool to define and create specific games, each methodology involves their specifications, tools, actors, levels and process of development. But how can designers choose the efficient and adequate methodology to their serious game application?

In this direction, our survey provides a decision support dedicated to designers and experts, in order to follow the adequate design methodology of their game achievement. Our classification deals with several serious game design methodologies with scope in learning and entertainment. According to the scope and objective of our study, we propose in this section new parameters to categorize serious games design using different classifications.

As it is illustrated in Fig.1, our classification is based on eleven related design subjects: category, level, layers, purpose, orientation, tools, process, applications, player, users, and evaluation.

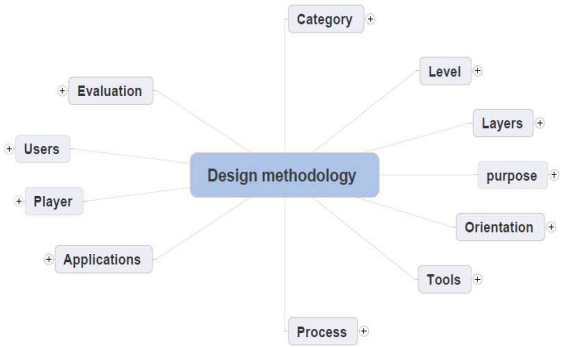

Figure1: Classification of game design methodologies

A. Design category:

Focusing on the category subject, the game design methodologies can be classified on two principals categories; methodologies designed to produce video games for entertainment and the ones for learning. This subject (see Fig.2) defines the design category of the methodology, entertainment discusses fun components: engagement, design of levels, scoring rules. However education involves learning and instruction requirements. The complexity of serious game design is how to merge education into the entertainment design.

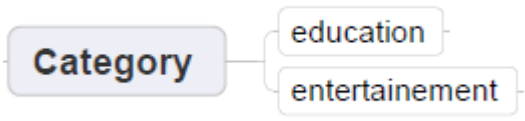

Figure 2: Design category

B. Level of design:

Serious games design relates the low level components (game mechanics, manipulation rules, user actions) to the high-level intentions (pedagogical intents, goals, rules, components of pedagogical value), several existing methodologies focus on the low-level or the high-level and others, recent studies, focus on the correlation between both levels. Fig.3 presents the high and low level, and the relationship mechanics employed to connect design levels.

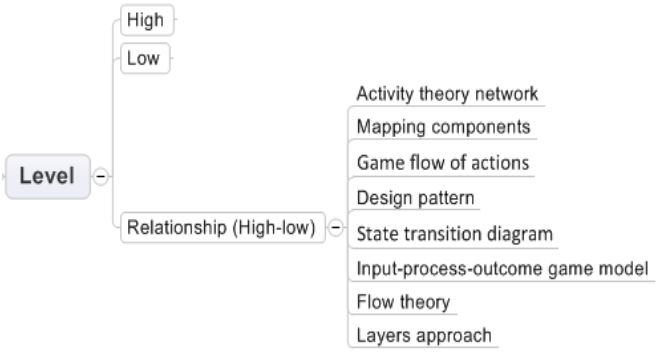

Figure 3: Design level

The low-level, in-game components, discuss the user interface or the implementation (Buttons, graphics, sounds, menu…) and the high-level provides the educational or entertainment goals and their requirements. In addition, the relationship between the two levels provides an intermediate layer between final goals analysis and the in-game elements.

C. Purpose:

The game design methodology can be used for several purposes, Fig.4 provides several final goals through the application of the methodology, and we define several methodology purposes: analysis, design, assessment-debriefing, goals evaluation. We difference two general analysis purposes of methodology: analysis for creating a new game, and analysis for evaluating an existing game or a prototype.

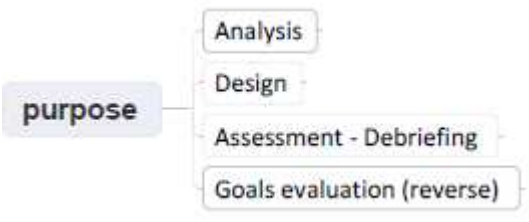

Figure 4: Design purpose

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For the analysis, the methodology assists the design actors to highlight the game specifications and requirements. This purpose provides an intrinsic data to design a new game or evaluate an existing game and design prototypes.

About the design purpose, the methodology involves processes and tools to support the design phase of game. Focusing on the assessment and debriefing, the methodology proposes the mechanics designed to evaluate the learning outcomes; it assists the experts and teachers to evaluate the player and provide player and expert feedback. The goals evaluation purpose provides tools and reports related to the final game and design prototypes evaluation; it highlights a visibility about the design process to define the required modifications for the design improvement.

D. Layers:

Serious games design on layers involves a decomposition of requirements on several components related to their function, the final goal and discussed content. Fig.5 provides the set of design layers highlighted in our study.

Figure 5: Design Layers

1) Pedagogy:

The pedagogy layer provides learning and instruction requirements related to the game purpose, it involves intentions, objectives, strategies, resources and interactions. The learning component focuses on learning objectives and content while the instructional component stresses the strategies adopted to teach the desired learning objectives. The difference is related to the subject of each component, while the learning corresponds to the point of view of the learner, the instruction depicts the side of the instructor(s) [6]. Several methodologies involve the pedagogical layer.

2) Story:

The story layer involves the requirements related to game story, it differences between the narration and storytelling; narration is designed to immerse players in the game as a powerful engagement factor to improve the learning outcomes. It involves the substrate narrative theories, branching, text…

The storytelling occurs during play phase, it combines the designer's story, narrative story, with the player follow experiences, the player interactions and choices.

3) Game-Gameplay:

The game play layer provides the game mechanics related to the design creation, this layer stresses requirements and specification of the game. The designer stresses the player actions, play strategies and motives. This is a common layer between all categories of games, serious game play stresses the intrinsic layer of integration between learning and entertainment to provide an efficient serious game.

4) Game-structure:

The game structure involves rules of play and simulation to provide an environment of challenges and fun.

5) Game-world:

The game-world focuses on fictional content (fantasy, narrative, imaginary…), topology/level design, textures... it provides requirements adapted to game presentation.

6) Technology: This is the lower layer of the game components; it focuses on the implementation, and game engine.

7) Assessment - debriefing: This layer is designed to specify the player's evaluation strategy; it can be an automatic assessment or based on debriefing sessions.

8) Assessment - design evaluation: The design evaluation provides the mechanics adopted to analyze the achieved prototypes and define the required modifications on design.

9) Social components: It represents an implementation of social tools such as Dialogue, network analysis (relationship, visualisation)…

E. Orientation:

We difference between two methodology orientations (see Fig.6). Firstly, theoretical concepts that involve taxonomy of pedagogy elements related to discuss the general analysis phase; it requires a deep expertise for users to build the analysis design. Secondly, practical

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methodology involves a set of step and diagrams to elaborate the analysis phases.

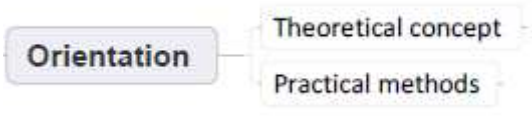

Figure 6: Orientation

F. Tool:

It stresses several tools employed to connect the analysis layers, we defined taxonomy classifications, graphical representations, set of question/responses, brainstorming process, OOP Concept, text description, prototype theory, game brick, activity theory.

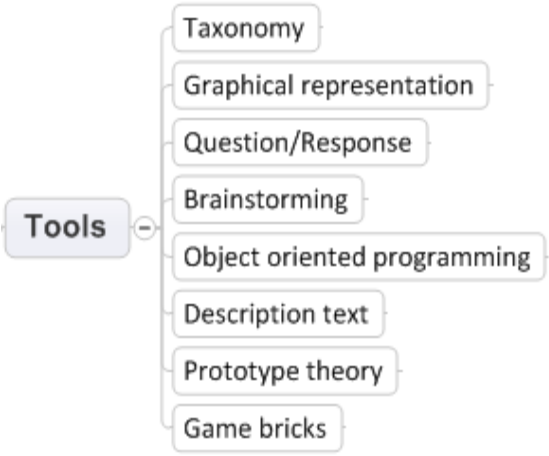

Figure 7: Design tools

G. Process:

Game process provides the cycle of game design, several methodologies stress the process adopted. We can find the rapid prototyping, prototyping, and experimental flow (see Fig.8).

Figure 8: Design process

H. Applications:

The design applications (see Fig.9) classify the topic and successful experimentation of design methodologies, the topic specifies the target of project supported by the methodology; small or big project. About the successful applications, we include here the domains considered by the different methodologies; we found Business, Health, Management, Security, and Entertainment. Some methodologies do not demonstrate the application of their concepts.

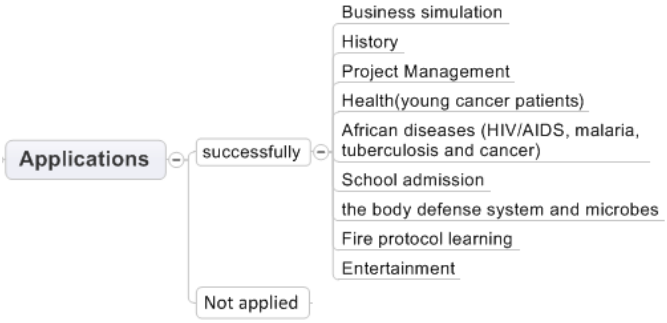

Figure 9: Design application

I. Player:

In this subject (see Fig.10), we project the design methodologies with focus on player considerations; we focus on the player specifications. We consider age, skills, challenges, conflict, progress, and engagement.

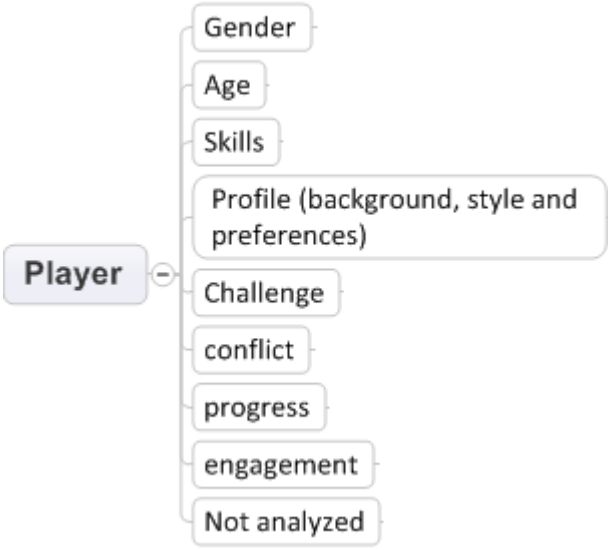

Figure 10: Player specifications

J. Users:

User methodology provides an important information (see Fig.11) to classify methodologies based on their users specifications, they can be designers, professors, domain experts, communication expert...

The contribution form involves the methodology vision about the project management; the methodology can have a specific model by role, or

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a common model (common languages) between all actors. In addition, it can provide a collaborative or an individual design.

Figure 11: user specification

K. Evaluation:

Fig.12 provides the classification of the current evaluation; it involves the attributes related to design validation.

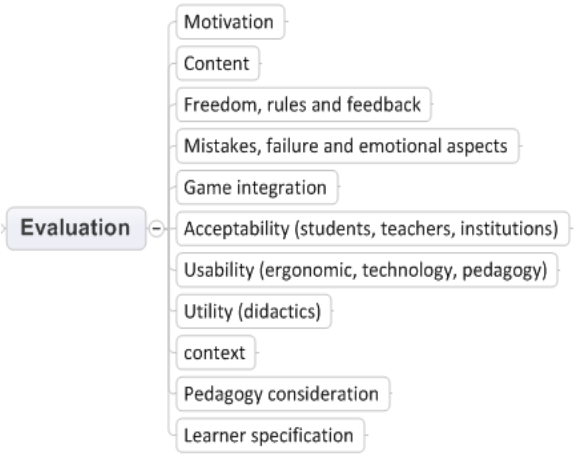

Figure 12: Evaluation

4. RESULTS

In this section, we present the surveyed game design methodologies with respect to the proposed classifications. To better present the results, we collect in Table1 the information of design methodologies for serious games. From left to right, column (1) contains the comparative attributes grouped according to the presented classification on previous section, from columns (2) to (15), we present the 14 design methodologies studied in the current paper. In Table1, rows have been grouped according to the proposed classification, from top to bottom, category, level, layers, relationship, purpose, orientation, tools, process, application, player, users, and evaluation.

DISCUSSION

The information collected from Table1 has been used to compare the characteristics of the surveyed serious games design methodologies with respect to different parameters. Below, from fig 13-27, we present the obtained results by graphical summary together with a brief description.

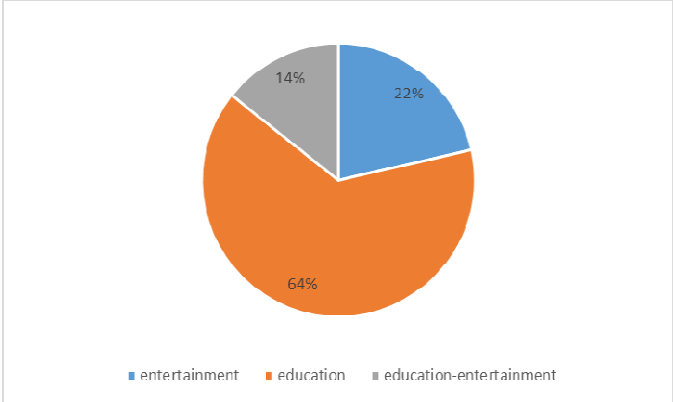

Figure 13: Breakdown of the "methodology category"

Fig.13 shows the production of the design methodologies according to the analysis category (educational and entertainment). It illustrates the percentage of methodologies for education with respect to methodologies for entertainment design. We observe that in design methodologies for analysis the education concept is about ninety percent more common than in design methodology for entertainment mechanics. About twenty percent only of design methodologies involve the relationship between education and entertainment mechanics.

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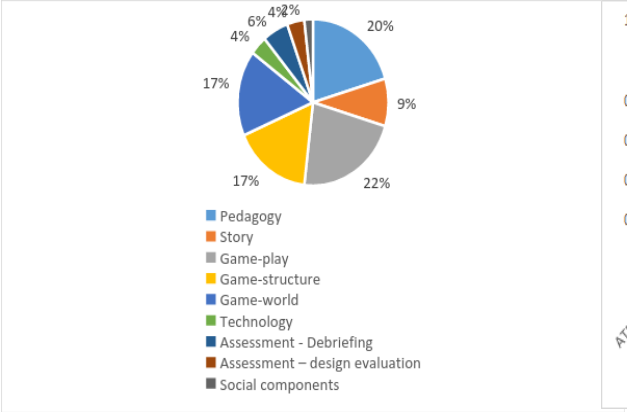

Figure 14: Breakdown of the "methodology layers"

Fig.14 presents the distribution of design methodologies according to the layers of analysis design; the chart shows the wide variety of the use of design methodologies on several layers. We observe that the majority of design methodologies have an orientation to the lower layers such as game-play with 22%, game-world with 17%, game-structure witch 17%, and story with 9%, however, about 20% methodologies involve the pedagogy layer into their analysis. We notice that methodologies have a low interest to other layers related to assessment, social-play, and technology.

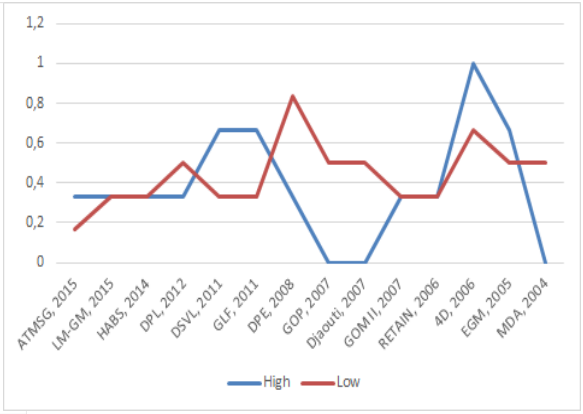

Figure 15: Breakdown of the "analysis level"

Fig.15 highlights the analysis level (high and low) according to the percentage of their implementation on methodologies, it illustrates that ATMSG, DSVL, GLF 4D, and EGM methodologies have a percentage of high level superior than low level of analysis design, the LM-GM, HABS, GOMII, and RETAIN methodologies have a balance between the high and low level analysis. The DPL, DPE, GOP, DJAOUTI, and MDA methodologies have a higher percentage of low level than the high level of analysis design; we notice that GOP, DJAOUTI, and MDA methodologies do not involve the high level in their design analysis.

Table1: Classification And Comparison Of Game Design Methodologies From Our Survey

Methodology		ATMSG 2015 [6]	HABS 2014 [7]	LM-GM 2015 [8]	GOMII 2007 [9]	LCRPDPL 2012 [10]	GLF 2011 [11]	4D 2006 [12]	RETAIN 2006 [13]	EGM 2005 [14]	GOP 2007 [15]	Djaouti 2007 [16]	MDA 2004 [17]	DPE 2008 [18]	DSVL 2011 [19]
Category	Entertainment	□	☑	□	□	□	□	□	□	□	☑	☑	☑	☑	□
	Educational	☑	☑	☑	☑	☑	☑	☑	☑	☑	□	□	□	☑	☑
Level	High	☑	☑	☑	☑	☑	☑	☑	☑	☑	□	□	□	☑	☑
	Low	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑
Layers: Final result product of model	Pedagogy	☑	☑	☑	☑	☑	☑	☑	□	☑	□	□	□	☑	☑
	Story	□	☑	□	□	□	□	□	☑	☑	□	□	□	☑	☑
	Game-play	☑	☑	☑	□	☑	□	☑	☑	☑	☑	☑	☑	☑	☑
	Game-structure	□	□	□	□	☑	☑	☑	□	☑	☑	☑	☑	☑	☑
	Game-world	□	□	☑	☑	☑	☑	☑	□	□	☑	☑	☑	☑	□
	Technology	□	□	□	□	□	□	☑	□	□	□	□	□	☑	□
	Assessment - debriefing	□	□	□	□	□	☑	☑	□	□	□	□	□	□	☑
	Assessment – design evaluation	□	□	□	□	□	□	☑	□	☑	□	□	□	□	□
	Social components	□	□	□	☑	□	□	□	□	□	□	□	□	□	□

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Relationship (High-Low)	Activity theory network	☑	☑	□	□	□	□	☑	□	□	□	□	□	□	□
	Mapping components	□	□	☑	☑	□	□	□	□	□	□	□	□	□	□
	Game flow of actions	☑	□	☑	□	□	□	□	□	□	□	□	□	□	□
	Design pattern	□	□	□	□	☑	□	□	□	□	□	□	□	□	□
	State transition diag.	□	□	□	□	□	□	□	□	□	□	□	□	□	☑
	Input-process-outcome game model	□	□	□	□	□	☑	□	□	□	□	□	□	□	□
	Flow theory	□	□	□	□	□	□	□	□	☑	□	□	□	□	□
	Layers approach	□	□	□	□	□	□	□	□	□	□	□	□	☑	□
Purpose	Analysis	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	□
	Design	☑	□	☑	☑	☑	☑	□	☑	☑	☑	☑	☑	☑	☑
	Assessment - Debriefing	□	□	□	□	□	☑	□	□	□	□	□	□	□	☑
	Goals evaluation (reverse)	☑	☑	□	□	□	□	☑	□	☑	□	□	□	☑	□
Orientation	Theoretical concept	□	☑	□	☑	☑	☑	☑	☑	☑	☑	□	☑	☑	□
	Practical methods	☑	□	☑	□	□	□	□	□	□	□	☑	□	□	☑
Tools used	Taxonomy	☑	□	☑	☑	☑	☑	□	☑	☑	□	□	☑	☑	□
	Graphical representation	☑	□	☑	☑	☑	□	□	□	☑	□	☑	□	□	☑
	Question/Response	☑	□	□	□	□	☑	☑	☑	□	□	□	□	□	□
	Brainstorming	□	□	□	□	□		□	□	□	□	□	□	□	□
	Object oriented programming	□	□	□	☑	□	□	□	□	□	□	□	□	□	□
	Description text	□	□	□	□	☑	☑	☑	☑	□	□	□	☑	☑	□
	Prototype theory	□	□	□	□	□	□	□	□	□	☑	□	□	□	□
	Game bricks	□	□	□	□	□	□	□	□	□	□	☑	□	□	□
Process Implemented	Rapid prototyping	□	□	□	□	□	□	□	□	□	□	□	□	□	□
	Prototyping	☑	□	□	□	□	□	□	□	□	□	□	□	☑	□
	Experimental flow	□	□	□	□	□	□	□	□	☑	□	□	□	□	
Applications	Business simulation	☑-	□	□	□	□	□	□	□	□	□	□	□	□	□
	History	☑	□	□	□	□	□	□	□	□	□	□	□	□	□
	Project Management	☑	□	□	□	□	□	□	□	□	□	□	□	□	□
	Health(young cancer patients)	□	□	☑	□	□	□	□	□	□	□	□	□	□	□
	African diseases (HIV/AIDS, malaria, tuberculosis	□	□	□	☑	□	□	□	□	□	□	□	□	□	□

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	and cancer)														
	School admission	□	□	□	□	☑	□	□	□	□	□	□	□	□	□
	the body defense system and microbes	□	□	□	□	☑	□	□	□	□	□	□	□	□	□
	Fire protocol learning	□	□	□	□	□	□	□	□	□	□	□	□	□	☑
	Entertainment	□	□	□	□	□	□	□	□	□	□	☑	□	□	□
	Not applied	□	☑	□	□	□	☑	☑	☑	☑	☑	□	☑	☑	□
Player specific ation	Gender	□	□	□	☑	□	□	□	□	□	□	□	□	□	□
	Age	☑	□	□	□	□	□	☑	□	□	□	□	□	□	□
	Skills	□	□	□	□	□	□	□	□	☑	□	□	□	☑	□
	Profile (background, style and preferences)	□	□	□	□	□	□	☑	□	□	□	□	□	☑	□
	Challenge	□	□	□	□	□	☑	□	□	☑	□	□	□	☑	□
	conflict	□	□	□	□	□	☑	□	□	□	□	□	□		□
	progress	□	□	□	□	□	☑	□	□	☑	□	□	□	☑	□
	engagement	□	☑	□	□	□	☑	□	□	☑	□	□	□	☑	□
	Not analyzed	□	☑	☑	☑	☑	□	□	☑	□	☑	☑	☑	□	☑
User role of method ology	Designer	☑	☑	☑	☑	☑	☑	□	☑	☑	☑	☑	☑	☑	□
	Teacher	☑	□	☑	□	☑	☑	☑	□	□	□	□	□	☑	☑
	Domain expert	☑	□	☑	□	☑	☑	□	□	□	□	□	□	☑	☑
	Pedagogical expert	☑	□	☑	□	☑	☑	□	☑	☑	□	□	□	☑	☑
	Communicati on expert	☑	□	☑	□	□	□	□	□	□	□	□	□	□	☑
	Developer	☑	□	☑	☑	□	□	□	□	□	□	☑	☑	☑	□
	Serious game research	☑	☑	☑	☑	☑	☑	□	☑	☑	□	□	☑	☑	□
	evaluator	☑	□	□	□	□	□	☑	□	☑	□	□	□	☑	□
	Not expert of game analysis/desig n	☑	□	☑	□	□	□	□	□	□	□	□	□	☑	☑
	Non domain expert	☑	□	☑	□	□	□	□	□	□	□	□	□	☑	□
User contribu tion form	Common Languages	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	☑	□
	Collaborative model	□	□	□	□	☑	□	□	□	□	□	□	☑	☑	□
	Specific model - use	□	□	□	□	□	□	□	□	□	□	□	□	□	☑
Design Evaluati on list (compar ative criteria)	Motivation	□	□	□	□	□	□	□	☑	□	□	□	□	□	□
	Content	□	□	□	□	□	□	☑	□	□	□	□	□	□	□
	Freedom, rules and feedback	□	□	□	□	□	□	□	□	☑	□	□	□	□	□
	Mistakes, failure and emotional aspects	□	□	□	□	□	□	□	□	□	□	□	□	□	□

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	Game integration	□	□	□	□	□	□	□	□	☑	□	□	□	□	□
	Acceptability(students, teachers, institutions)	□	□					☑		□	□	□	□	□	□
	Usability(ergo nomic, technology, pedagogy)	□	□	□	□	□	□	☑	□	□	□	□	□	□	□
	Utility (didactics)	□	□	□	□	□	□	☑	□	□	□	□	□	□	□
	context	□	□	□	□	□	□	☑	□	□	□	□	□	□	□
	Pedagogy consideration	□	□	□	□	□	□	☑	☑	☑	□	□	□	□	□
	Learner specification	□	□	□	□	□	□	☑	□	☑	□	□	□	□	□

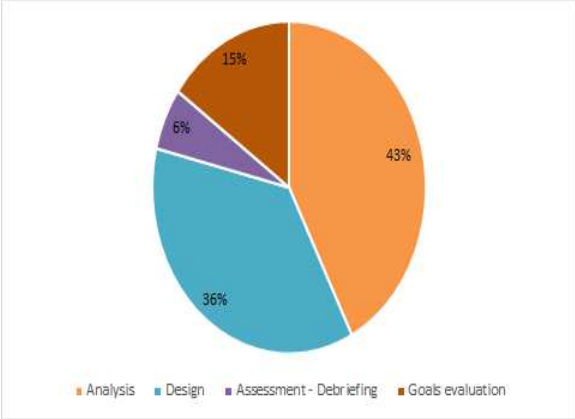

Figure 16: Breakdown of "methodology purpose"

Fig.16 presents the distribution of methodology purpose according to the final goals achieved. The chart shows the wide variety of the purposes between analysis, design, assessment-debriefing, and goals evaluation. We observe that the important variety of methodologies purposes are the analysis with 43% and design 36%. On the other side, a few methodologies involve the assessment (6%) and evaluation (15%) on their purposes. We notice that methodologies have a low interest to assessment and design evaluation goals.

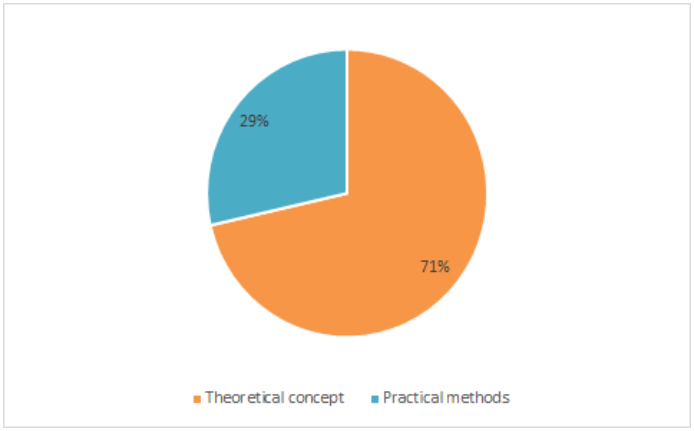

Figure 17: Breakdown of "Design orientation"

Fig.17 shows the distribution of methodologies orientation between practice and theory, methodologies with theoretical orientation represent the majority with 71%, and however 29% of methodologies highlight the practical methods.

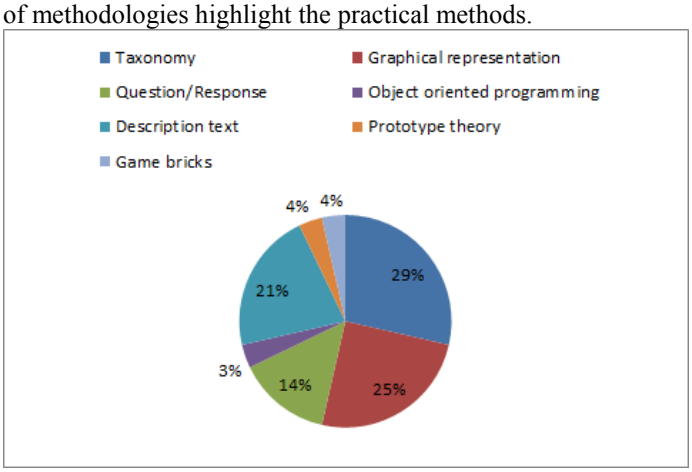

Figure 18: Breakdown of the "Tools used"

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Fig.18 presents a distribution of the tools employed on methodologies to obtain the final goals; the chart shows a variety between taxonomy, graphical representation, text distribution, question/response, OOP, prototype theory, and game bricks. The higher percentages correspond to taxonomy (29%), graphical representation (25%), text distribution (21%) and 14% for Q/R tool. However, a few methodologies employ game bricks (4%), prototype theory (4%), and oriented object programming (3%).

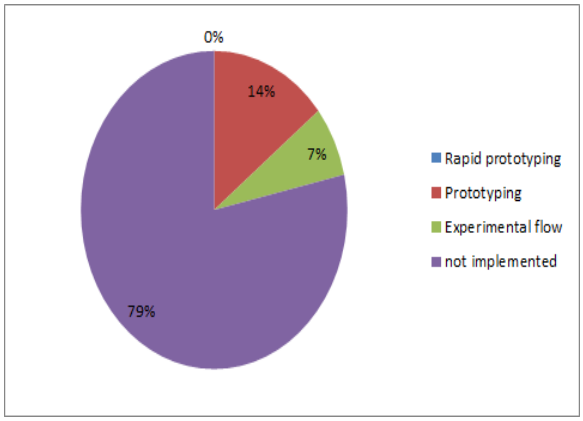

Figure 19: Breakdown of the "Process Implemented"

Fig.19 presents the distribution of implementation of several design processes through the presented methodologies, the chart shows a prevalent class (79%) of not implemented design process, 14% of methodologies implement the prototyping process, 7% involves the experimental flow and no methodology implements the rapid prototyping.

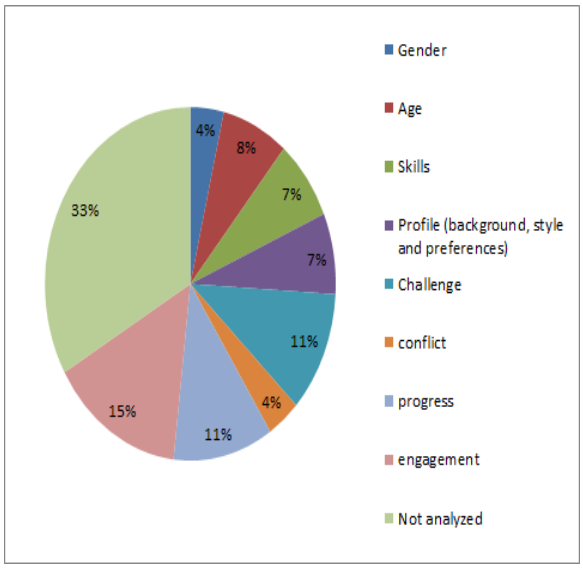

Figure 20: Breakdown of the "Player specification"

Fig.20 displays the distribution of methodologies according to the "player specification". The chart illustrates that 33% of methodologies do not involve the player specification through their analysis process, however, several methodologies analyze the engagement (15%), progress (11%), challenge (11%), age (8%), skills (7%), profile (7%), gender (4%), and conflict (4%).

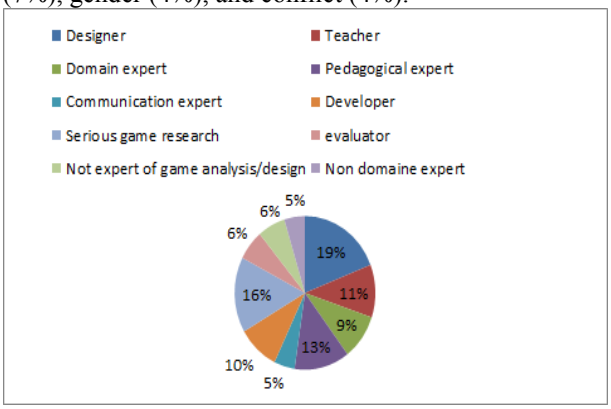

Figure 21: Breakdown of the "Methodology roles"

Fig.21 highlights the distribution of methodologies according to their required user roles; the chart shows the wide variety of roles, designer (19%), serious game researcher (16%), pedagogical expert (13%), teacher (11%), developer (10%), domain expert (9%), and evaluator (6%), non-expert of game design (6%), non-domain expert (5%), and communication expert (5%).

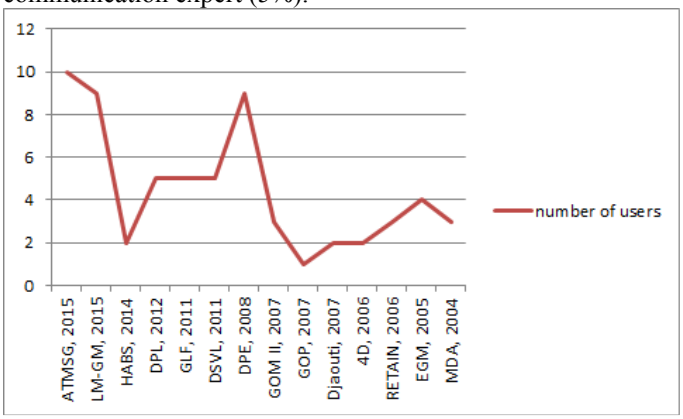

Figure 22: Breakdown of the "number of user roles"

Focusing on the number of roles according to the specific methodology, Fig.22 illustrates that methodologies of ATMSG, LM-GM, and DPE are designed for high number of users (8-10), methodologies of DPL, GLF, DSVL, EGM, GOM II, and 3 to 5 users can use MDA. Finally, methodologies of HABS, Djaouti, 4D, and GOP involve 1 to 2 users.

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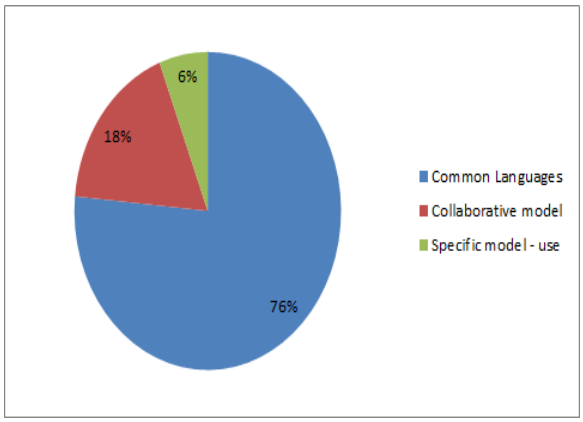

Figure 23: Breakdown of the "Contribution form"

The contribution from provides an additional mean to methodology user roles; it defines the adopted form of users' collaboration. Fig.23 displays the distribution of methodologies according to the user contributions, we find that the wide variety of methodologies provides a common language (76%) way to discuss design. 18% of methodologies involve collaboration between their users, and only 6% of methodologies provide a specific analysis for each user.

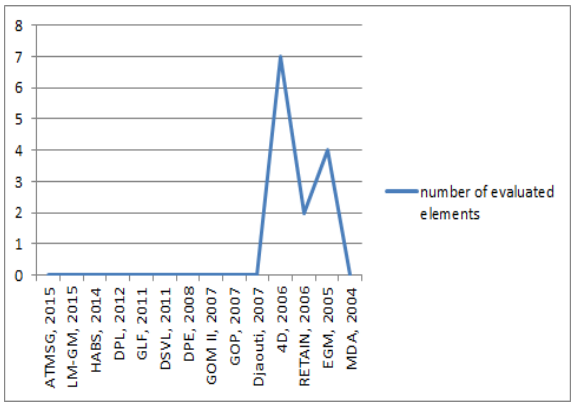

Figure 24: Breakdown of "Design evaluation elements"

Regarding to the design evaluation, fig.24 stresses the number of evaluated elements according to methodologies, it illustrates that only three methodologies involve evaluation through their analysis. Although, 4D, Retain, and EGM study between 2 and 7 elements in order to evaluate design, other methodologies do not provide any evaluation components.

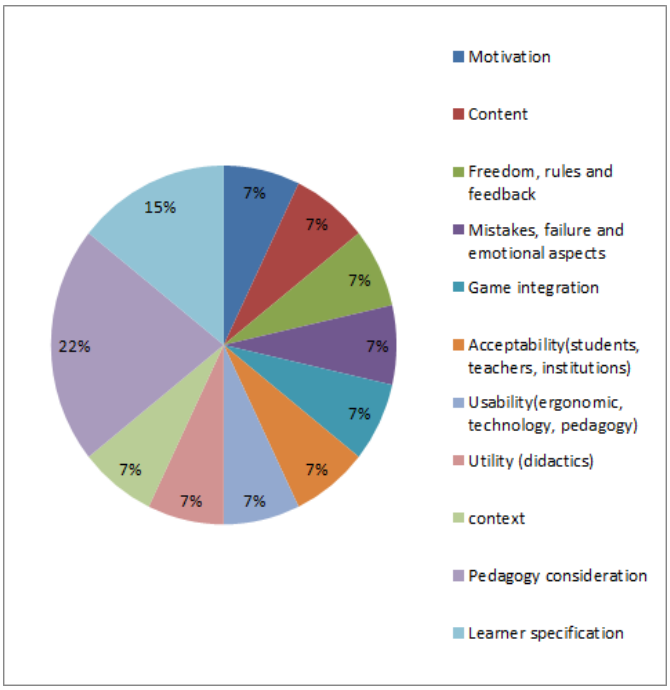

Figure 25: Breakdown of "Design evaluation"

Following the design evaluation component, we study also the distribution of methodologies according to the evaluated element; Fig.25 highlights 11 characteristics defined form the comparative study. It presents a wide variety of the game usability and learner specification, and a quite variety of other features.

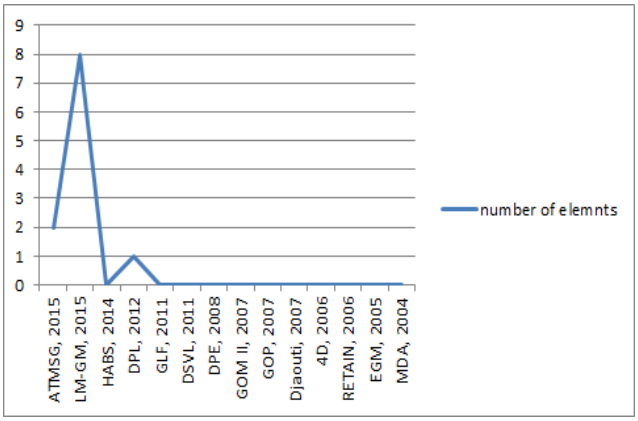

Figure 26: Breakdown of "Methodology evaluation"

Related to design evaluation, we can also study the evaluation of the methodology adopted and their comparison with other methodologies, a quite variety of methodologies involve this evaluation in their papers such as ATMSG, LM-GM and DPL, although other methodologies do not specify this evaluation.

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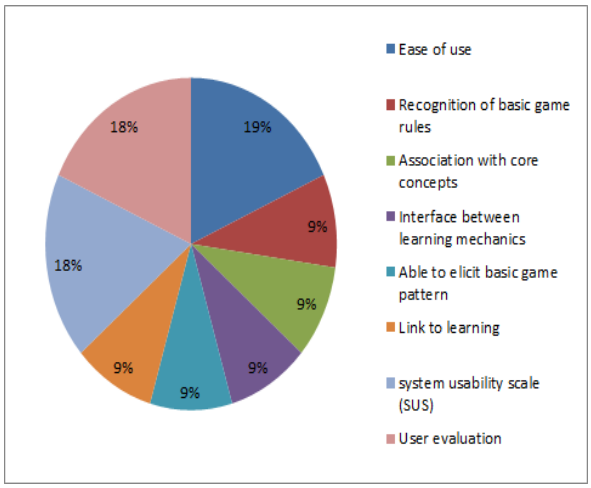

Figure 27: Breakdown of "Methodology evaluation"2

Fig.27 shows the features involved in methodologies to evaluate their applications, it illustrates a wide variety of "easy to use" (19%), "user evaluation" (18%), "system usability scale" (18%), and 9% for other evaluation elements.

5. CONCLUSION

We have studied fourteen design methodologies from learning and entertainment purpose, they have been classified according to their main category (entertainment, and learning), levels (high, and low) and their relationship, layers (pedagogy, story, game-play, game-structure, game-world, technology, assessment – debriefing, assessment – design evaluation, and social components), purpose (analysis, design, assessment – debriefing, and goals evaluation), orientation(theoretical concept, and practical methods), user roles of methodology (designer, teacher, domain expert, pedagogical expert, communication expert, developer, serious game research, evaluator, not expert of game, analysis/design, non-domain expert), contribution form (common languages, collaborative model, specific model - use). Additionally, seven criteria dealing with the specifications have been selected for classification: tools, adopted process, applications, player specification, and design evaluation.

We did a statistical analysis of different variables of serious game design to see if methodologies fill gaps on certain design requirements; it defines a dashboard for future research and designers to find a coherent methodology for serious game design. Our results show that the existing methodologies have studied the high and low levels of serious game design using theoretical tools and concepts for the design actors. Several directions should be further developed, in particular, the study of the correlation between the pedagogical and entertainment level, tools for the collaborative interaction between the several design actors (expert, designer, and player), and finally assessment methods for the evaluation of design goals and player outcomes.

The detailed description and classification of all the previous successful methodologies presented here can be useful for researchers developing new methodologies by raising the awareness of the different possibilities. While we cannot make hard predictions on the future of serious games design, we expect two different directions: new, innovative methodologies exploring the rest of the parameter space of our classification, and more classic methodologies concentrating on the most commonly used features.

As a future trend, we expect that the correlation between design and evaluation through a collaborative design framework will dominate the serious games design, given the increasing accessibility, in particular to software students and junior designers, to apply methodologies in serious game design. We also expect the high interaction between expert and designer will lead to a powerful tool for learner outcomes.

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