The Principal Characteristics of a Serious Game to Ensure Its Effective Design

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ABSTRACT
Serious games (SG) adoption increased in multiple fields. As a first step towards a global SG design approach, it is crucial to characterize the game intended. However, there is still a lack of what the principal and necessary characteristics are to specify SG. This paper explores SG Characteristics (SGCs) to bridge this gap by first analyzing features from SG studies in different domains (education, health, business) and purposes (SG classification, learning impacts, design, and evaluation), then identifying shared features. The findings showed 12 high-level abstraction classes of characteristics, which we named Common SGCs (CSGCs), reducing features overlapping and describing the general structure of the game. The CSGCs set serves as a foundation for SG design and reusability. It also provides the main criteria for SG classification and evaluation. Designers could implement CSGCs by matching each one of them with related concrete game mechanics plethora. We present future research directions in the scope of the SG design approach using the CSGCs proposal.

Keywords
Game design, game features, game specification, serious games, serious game characteristics.

INTRODUCTION
Playing games is practiced by a large and growing percentage of the population, not only for leisure but also for learning, improving skills, or training (Deterding et al. 2011; Nakatsu et al. 2015; Perez-Colado et al. 2018). Namely, Serious Games (SG) have the advantages of offering possibilities to engage and motivate players in reaching serious purposes (Boyle et al., 2016; Charsky, 2010; Connolly et al., 2012; Laamarti et al., 2014; Lameras et al., 2017; Lang, et al., 2014). Therefore, the adoption of SG is increasing in multiple fields such as health, defense, education, marketing, business, and research as tools for learning, training, improving skills, therapy, assessment, and recruitment (Allal-Chérif, 2014; Boughzala and Michel, 2016; Michael et al., 2005; Zyda, 2005). As multidisciplinary software, the design of SG is a crucial task due to the complex nature of game characteristics. Currently, many SG design studies provide methods and approaches to specify the Serious Game Characteristics (SGC) within the

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game design process. However, these works focus on games for a specific application area and do not help understand the necessary characteristics which support analysis and more effective game design, and designers should adopt to define SG components in any domain. By SG components, we mean the game elements being involved.

In the literature, many works have focused on SGCs, deal with a particular area (e.g. education, health care, business, and culture), and a specific SG study purpose (e.g. classification research (Djaouti et al. 2011; Wattanasoontorn et al. 2013; Rego et al. 2010; Bedwell et al. 2012; Laamarti et al. 2014; Heintz and Law, 2015), impacts and learning outcomes (Abdul Jabbar, 2015; Qian and Clark, 2016), design (Avila Pesantez et al., 2017; Carvalho et al., 2015; Lameras et al. 2017), and evaluation (Abdellatif et al. 2018; Desurvire and Wiberg 2009). For example, Wattanasoontorn (2013) examined SG for health and used fourteen relevant characteristics such as competition and goals, challenges, adaptability, and game genre to classify more than one hundred games for health. Charsky (2010), Abdul Jabbar (2015), and Heintz (2015) investigated SG features that promote engagement and learning in educational settings as competition, challenges, choices, and interactivity. Most researchers defined SG as software with a dual role: entertain and carry out a serious objective (Dörner et al., 2016; Michael et al., 2005; Zyda, 2005). Accordingly, Wattanasoontorn (2013) and Djaouti (2011) distinguished two types of SGCs, those related to divertissement and those related to the content of the objective intended. Yet again, the question of the main characteristics that describe the game components remains unsolved. Moreover, all the reported characteristics are meld to each other. For example, Charsky (2010), Laamarti (2014), Wattanasoontorn (2013), Djaouti (2011), and Bedwell (2012) used many attributes such as challenge, surprise, mystery, adaptability, complexity, location, mobility, interaction, modality, market, and application area without distinction of the relationship between them. In addition, there is no consensus about the SG characteristics categorization and their context of use. Meanwhile, common vocabulary characterizing SG is practical and needed to achieve productive partnership between experts from various fields and the SG design team and support the game specification for more effective design.

In contrast to existing works previously mentioned, this work aims to identify the characteristics that specify SG in any domain. To achieve this goal, first, we surveyed relevant SG researches in the last decade that examined SG attributes in various settings, application areas, and objectives. Then, we proposed a set of 12 generic SGCs, called Common Serious Games Characteristics (CSGCs), with a unified and meaningful terminology. The CSGCs, as a generic game features set, provide guidelines and criteria to specify, compare, classify, and evaluate SG in any domain. The rest of the paper is divided into four sections. In the first one, we introduce the concepts of SG and its characteristics and present the scope of works reviewed. The second section shows the methodology used to conduct this study. In the third section, we expose and discuss the reviewing results and our CSGCs suggestions. We conclude this work with a summary of our investigation and future research directions in the last section.

SERIOUS GAME CONCEPT AND ITS CHARACTERISTICS USE

A game, in general, is defined as physical or mental contests and activities with a goal or objective (Wattanasoontorn *et al.,* 2013). Charsky (2010) observed that games are controlled by rules and constraints that limit the actions a gamer can and cannot take inside the game world to achieve the intended goal.

Serious game concept

Many SG definitions are proposed in the literature. The first one was introduced by Abt in 1970 as a simulation to improve education in or outside the classroom (De Lope et al., 2017; Djaouti et al., 2011). Next, the term "serious games" took shape with Zyda (2005) who differentiated between a video game as an entertainment game used for just amusement and a serious game as a game that uses entertainment to accomplish an objective as learners' motivation and engagement, improving skills, or training. Since then, the concept of the serious game has been analyzed.

Serious Game characteristic concept

Many terms in the literature referred to game characteristics such as feature (Lameras et al., 2017; De Lope et al., 2017; Abdul Jabbar et al., 2015), attribute (Abdul Jabbar et al., 2015; Bedwell et al., 2012), factor (Laamarti et al., 2014), criteria (De Lope et al., 2017; Djaouti et al. 2011), characteristic (Charsky, 2010), and game element (Deterding et al., 2011; Qian and Clark, 2016; Arnab et al., 2015; Heintz and Law, 2015) all of them were used to express the core game elements. In this work, we adopt the term SG Characteristic (SGC) in the same meaning. Game characteristics were also related to the generated outcomes. For example, Sweetser (2005) identified eight computer game features, including challenges, control, clear goals, immersion, and social interaction that generate player enjoyment. From another standpoint, competition and goals, rules, choice, challenges, and fantasy characteristics, were identified by Charsky (2010) as influencing motivation and facilitating learning. Most of SGCs are interdependent, and there is no unified description of any of them. To fix this research gap some works attempted to group SGCs into categories (Bedwell et al., 2012; Djaouti et al., 2011; Shu and Liu, 2019; Wattanasoontorn et al., 2013). For instance, Heintz (2015) summarized the main game characteristics, including those influencing learning in digital educational games. The proposed model exposed some game elements, including gameplay, rules, goals, and rewards based on Bedwell's (2012) categories as core components of the game. Some researchers affirm that all games having structural rules and goals share some basic characteristics (Charsky, 2010; Dörner and Göbel, 2016). Based on SG studies, Dörner (2016, p59-61) also investigated game features and showed that some common game characteristics contribute to player's engagement, such as play, rules, storytelling, social factors, and learning. In this work, we analyzed SGCs in recent research (between 2010-2019) having different application areas and purposes and built the common SGCs with a high level of abstraction based on all the collected features.

Scope of the SGCs investigation

To reach the broad and meaningful characteristics that define the core game components in this paper, we investigated SGCs from different perspectives. The first one was SG classification in general (Laamarti et al. 2014; Boughzala and Michel, 2016; De Lope et al., 2017; Djaouti et al.2011; Bedwell et al., 2012). For example, Bedwell (2012) explored SG features such as challenge, conflict, fantasy, interaction, rules/goals, and location to develop a taxonomy of SGCs. Similarly, Laamarti (2014) classified SG based on SG characteristics including, activity, modality, application area, interaction style, and location used in SG design and development. Based on previous classifications, Djaouti (2011) proposed a Gameplay, Purpose, and Scope (G/P/S) model to classify SG using three SGCs categories: gameplay which refers to the game structure, game objective and target domain, and audience. Besides, De Lope and Medina (De Lope and Medina-Medina, 2017) provided a comprehensive taxonomy of SG, in general, using 16 characteristics. Authors regroup them into six classes, including game development, game design, and game platform. Furthermore, we extended our investigation on the SG classification in specific application areas, including health (Wattanasoontorn et al., 2013), business and industry (Riedel and Hauge, 2011), and education (Lameras et al., 2017; Avila Pesantez and Rivera, 2017).

In this work, the list of domains is not exhaustive yet varied and meaningful. In the health domain, Rego (2010) investigated features that allow SG classification. Accordingly, the author indicated that SG for rehabilitation has a great potential to motivate and engage patients with impairments and disabilities. The results exposed ten characteristics including, application area, interaction technology, game interface, and adaptability.

The second research scope is SG design, in which the researchers analyzed the main features that influence positive outcomes of the objective intended then integrated them into the game design. Charsky, (2010), Abdul Jabbar (2015), and Qian (2016) examined game design features that promoted engagement in Game-Based Learning (GBL) settings and noted that characteristics such as challenges, competition, and narrative content enhance motivation and facilitate learning. In this perspective, Avila Pesantez and colleagues (2017) proposed the list of the main characteristics related to each SG design phase, analysis, design, development, and evaluation. The last perspective through which SGCs, are examined is evaluating SG (Abdellatif et al., 2018; Desurvire et al., 2009). For example, Abdellatif (2018) proposed a framework to evaluate SG based on two classes. In the first one, the author grouped primary quality characteristics and mentioned that their absence affects the relevance of the intended objective including, usability, understandability, and pedagogical aspects. The other class contains secondary quality characteristics that aren't crucial to the success of SG and have limited usage in evaluating frameworks such as social impact and cognitive behavior.

SEARCH STRATEGY

This study draws upon relevant research papers selected from the last decade and shares descriptions and analyses of SGCs. Indeed, we adopted a research strategy based on a four phase-process: Preparation, Pre-selection, Analysis, and Approve.

Preparation phase

The preparation phase was conducted in three steps. Firstly, we defined the data collection built on journals, conferences, and proceedings identified as a source of information in the SG domain. The searched databases, including those identified as relevant to computer sciences, education, business, and health care, were: ACM (Association for Computing Machinery), ECONBIZ, Emerald, ERIC (Education Resources Information Center), IEEE eXplorer Digital Library, SAGE Journals, PubMed, Science Direct Elsevier, Springer, and Taylor & Francis. In a second step, we defined the search query based on five aspects: (1) serious games, (2) serious game characteristics, (3) taxonomy and classification of SGs, (4) SG design, and (5) impacts and outcomes of SG. The query used was (" taxonomy" OR "classification" OR "design" OR "learning outcomes" OR "evaluation" OR "characteristic") AND ("serious games" OR "computer games" OR "games-based learning" OR "online games"). In the last step, we evaluated the research results. Indeed, we noticed a lack of works having the main purpose concerning SGCs. To reach a greater number of relevant papers, we adjusted the initial query by adding many synonyms matching characteristics, including features, attributes, criteria, factors, game elements, and game mechanics. This is (" taxonomy" OR "classification" OR " design" OR " learning outcomes" OR "evaluation" OR "characteristic" OR "feature" OR "Attribute" OR "criteria" OR " factors" OR "game elements" OR "game mechanics") AND ("serious games" OR "computer games" OR "games-based learning" OR "online games"). Thus, a significant number of works were retrieved by our query that combined all aspects mentioned above.

Pre-selection phase

To refine results, we followed the preparation phase by a pre-selection phase that equally goes through three steps. In the first one, we applied a search filter with a date range between 2010 and 2019 and the English language. When the number of works remained high (> 10000 per database), we employed other filters according to the options offered by the database. In such case, we specified topics and/or domains as education, human-computer interaction, computer sciences, business and industry, and health. Figure 1 illustrates the results obtained per database at the end of this step. In the next step, we refined the results by checking the inclusion criteria. These criteria were: overall articles from 2010 relevant to one or many of the five research aspects mentioned above, published ideally in journals or conferences and described and enumerated SGCs. In a third step, we used exclusion criteria to refine the selection of retrieved works. Duplicating articles and dealing with the only specific use of SG, such as simulation, a particular sector in a domain, audience-specific needs, or a game case study, were excluded.

Analysis phase

The papers generated by the pre-selection phase were examined by a general review of the title, abstract, keywords, and conclusion, followed by the authors snowballing investigation. Then we retained papers matching the most to the scope of this research. The papers obtained (64) were added to our references library, as shown in Figure 2. We have noticed much redundancy according to our search objective (SGCs in general). Hence, we examined the content of the papers analyzed in the approval phase.

Approval phase

Before the final selection of papers reviewed in this work, we estimated their relevance according to the SGCs significance (not previously retrieved in the same context and well-described). For example, 15 pre-selected papers focused on learning outcomes of GBL. But, after we considered the contents, most of them were verified haven't significant differences concerning SGCs. As a result, we retained only three papers for the final review. Besides, not all retrieved SG design works (N=14, see Figure 2) described characteristics or showed how they influenced the design. As a result, we retained only two papers for the final review. The first one is (Abdul Jabbar and Felicia, 2015) selected because the authors presented the highest number of characteristics (49). The second one is (Avila Pesantez and Rivera, 2017), in which authors described features per game design phase. Finally, we retained 14 SG studies that examined 286 characteristics related to the SG structure, as shown in Table 1.

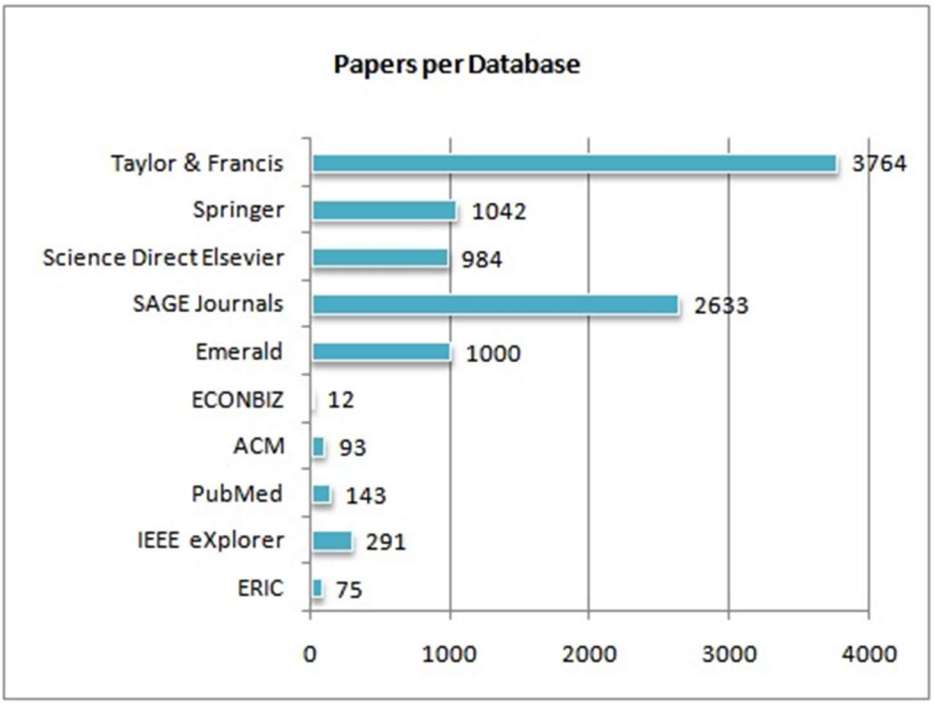

Figure 1: Number of works retrieved per database collection after filter.

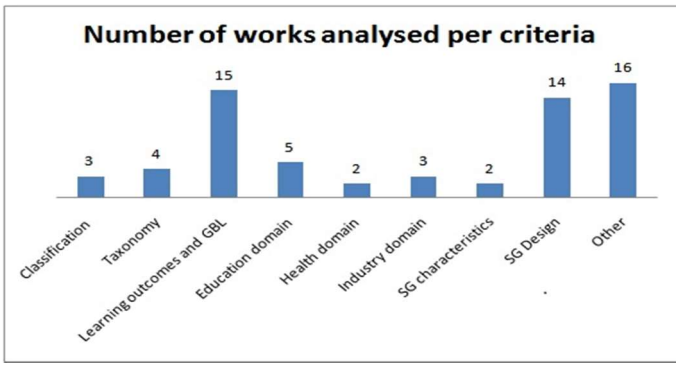

Figure 2: Distribution of the works pre-selected matching the scope of this work

Source	Purpose of examining SGCs/ Domain	Number of SGCs (number of categories)
(Charsky, 2010)	Motivation and facilitating learning / Education	5 (0)
(Rego et al., 2010)	Study of SGCs and classification/ Rehabilitation domain	10 (0)
(Djaouti et al., 2011)	Classification/ All domains	8 (3)
(Riedel and Hauge, 2011)	Study of SGCs/ Business and industry	6 (0)
(Bedwell *et al.*, 2012)	Taxonomy/ All domains	19 (9)
(Wattanasoontorn *et al.*, 2013)	Classification / Health domain	21 (4)
(Laamarti et al., 2014)	Classification/ All domains	10 (5)
(Abdul Jabbar et al., 2015)	Impact of game design on learning outcomes/ GBL	49 (6)
(Qian and Clark, 2016)	Impacts on students skills /GBL	28 (0)
(Lameras *et al.*, 2017)	Taxonomy/ Higher education field	40 (5)
(Avila et al., 2017)	Learning outcomes / Academic setting	40 (4)
(De Lope et al., 2017)	Taxonomy of SG in general/All domains	16 (6)
(Abdellatif et al., 2018)	Evaluating SGs using quality characteristics	18 (2)
(Shu and Liu, 2019)	SGs impact and Learning outcomes/ GBL	16 (7)

Table 1: Summary of the selected works

RESULTS AND DISCUSSION

In this paper, we focus on fundamental characteristics that specify the SG game structure in any domain. In this regard, firstly, we examined the SGCs given by each work reviewed according to its study purpose. Then, we analyzed characteristics that define, compare, and classify SG. Moreover, those promote the intended objective of designing them, such as motivation, engagement, and improvement of learning outcomes. As shown in Table 1, most works (10 out of 14) regrouped the characteristics into categories. The total characteristics number examined in this work is 286. The maximum number of features per paper is 49, presented to study the impact of game design on learning outcomes in the GBL context. The minimal number is five characteristics introduced as facilitating learning in the education setting. The results also show no matching between reviewed researches neither in SGCs number nor in categories number, even if works have the same purpose and/or domain. For example, Djaouti (2011) examined eight characteristics grouped in 3 aspects, Bedwell (2012) investigated 19 attributes by nine categories, Laamarti (2014) used 10 SGCs grouped

in 5, and De Lope (2017) 16 in 6 when all of them have as main purpose SG classification in all domains. Another example, both Charsky (2010) and Pesantez (2017) investigated SGCs that improve learning outcomes in the education setting. The first author asserted that five characteristics (competition and goals, rules, gameplay, challenges, and fantasy) influence learning outcomes. Yet, the second defined 40 SGCs that affect the design of educational games and improve learning outcomes.

The results provide two clues, (1) researchers examine SGCs to support their SG studies by many domains and various purposes including, game design, and (2) the works reviewed shared the use of many characteristics. First, this indicates that identifying characteristics is crucial when dealing with SG. Especially in the game design process, a basic SGCs list will support the collaboration between domain experts and designers and facilitate the game specification. Second, SG could be defined by some generic characteristics.

As the case with all reviews, the current study was limited by the search terms used, the journals included and the period of articles published. However, the papers discussed in this literature overview provide a diversity of recent SG research on outcomes and impacts, design, classification, and evaluation. These papers are based on effective and relevant previous SG works and cover multiple SG application areas including, education, health, and business. The review was selective and still excluded relevant papers because this work needs to diversify the purposes of the studies and eliminate redundancy without worth value according to our SGCs understanding and new characteristics disclosure. In this study, we analyzed the content of a broad number of papers (64) and retained only 14. However, an approval phase second iteration of our search strategy may be applied to increase the number of selected works.

CSGCs proposal

As mentioned above, we propose a generic list of game components after analyzing the surveyed SGCs. We start by aggregating those related to the game aspect and have a similar objective of use or synonym names and are strongly related or interdependent. Then verify that the group is crucial, and characterize the game. Finally, we assign a generic and meaningful name to the group and provide a description. For example, Complexity, Challenge, Surprise, Competition, Explanation, and Adaptability SGCs, are grouped under the generic "Adaptability" label. We assigned the name "Common" to the group since it specifies SG in any domain including, education, health, and business. The majority SGCs included were used by researchers for multiple SG study purposes including game design, classification, and evaluation. The proposal covers 12 CSGCs presented in Table 2. Column 1 shows the name we chose for each generic characteristic. In column 2, we give a unified description of each CSGC proposed. Column 3 shows the SGCs grouped from works reviewed and having the same characterization or context of use. The last column indicates the source. These are Adaptability, Assessment, Enjoyment, Gameplay, Activity, Environment, Interactivity, Collaboration, Game purpose, Application area, Target audience, and Technical features. The CSGCs list is consistent with some empirical studies since most CSGCs match their findings (Shu and Liu, 2019; Laamarti et al., 2014; Wattanasoontorn et al., 2013; Avila Pesantez, 2017; Riedel and Hauge, 2011). Explicitly, Wattanasoontorn (2013) surveyed 108 SG for health with various game objectives such as professionals and non-professionals training, health and wellness, rehabilitation, treatment, detection, and education. It has been shown that the majority of them include Adaptability (80.56%), Progress monitoring (82.41%) and Performance feedback (72.22%), and Hardware portability (91.67%) characteristics. These characteristics are included in our CSGCs proposal. Likewise, classification criteria by De Lope (2017), (13 out of 16), Bedwell (2012), (17 out of 19), Laamarti (2014), (10 out of 10), and Djaouti (2011) (5 out of 8) were covered also by our CSGCs suggestion. Moreover, most characteristics

surveyed in this work (170 out of 286) are covered by CSGCs. From a software viewpoint, 12 CSGCs denote game requirements that designers should focus on to specify the intended game. Furthermore, each of them could be implemented by a plethora of concrete game mechanics, as shown in Figure 3. In summary, CSGCs proposal is a generic set of SG characteristics that can be used to define the core component of SG in many contexts such as SG design, classification, evaluation, and research. A practical application of CSGCs can be conducted in a game design project, where domain experts could express their requirements and collaborate with designers to describe the game intended using CSGCs. But it is not in the scope of this work. For example, healthcare professionals, managers, or teachers can accurately specify the intended SG by selecting CSGCs matching their needs. Then, domain experts can collaborate with the designer team and determine the adequate game mechanics that implement each adopted CSGC accordingly to the game purpose. During the entire SG development process, the proposed CSGCs list provides a shared reference by all of the stakeholders including domain experts, designers, artists, and developers. Besides, this list can be used to evaluate the SG consistency and quality, according to the CSGCs specification already made. Following, we detail only some of the CSGCs including, Adaptability, Assessment, and Enjoyment due to space restrictions.

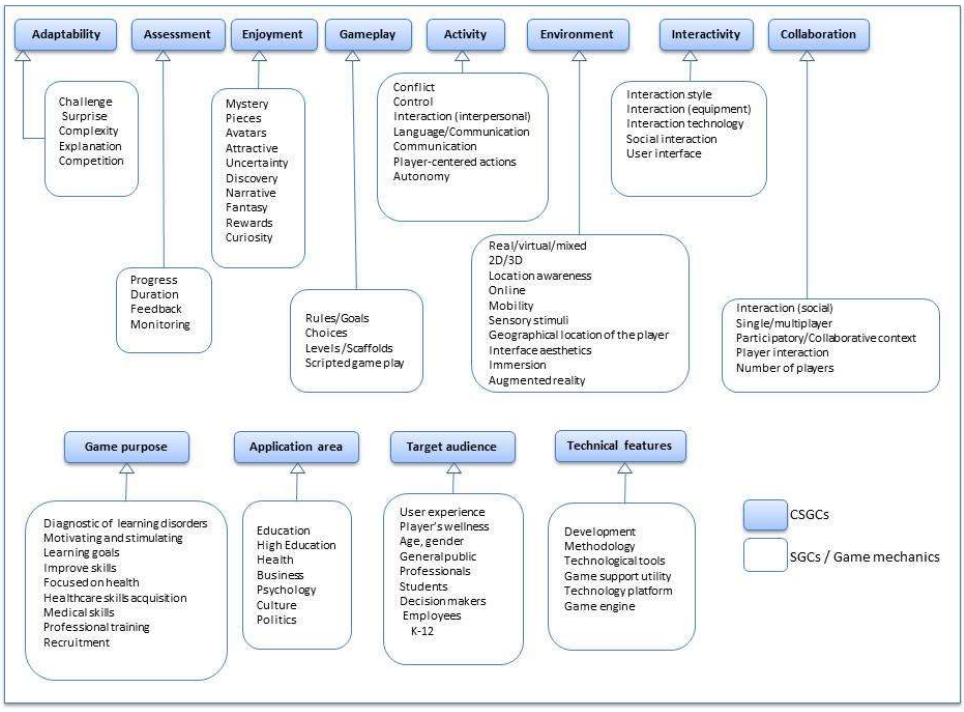

Figure 3: Examples of SGCs and game mechanics matched with CSGCs

Proposed CSGCs	Description	SGCs	Source
Adaptability	SG level of difficulty, complexity, challenges and surprise elements adjusts to player skills, and intended goals.	Adaptation, Challenge, Surprise.	(Bedwell *et al.*, 2012)
		Game complexity, duration of activities within the game.	(Avila Pesantez et al., 2017)
		Complexity, Challenge, Surprise, Competition, Explanation.	(Qian et al., 2016)
		Adaptability.	(Wattanasoontorn *et al.*, 2013),
		Adaptability.	(Rego et al., 2010)
		Competition and Goals, Challenges.	(Charsky, 2010)
		Adaptation.	(De Lope et al., 2017)
		Tasks/Challenges.	(Lameras *et al.*, 2017)
		Competitive.	(Abdul Jabbar et al., 2015)
		Usability, Understandability, challenge, competence, Difficulties, Time to complete the game.	(Abdellatif et al., 2018)
		Challenge, Competence/skill.	(Shu and Liu, 2019)
Assessment	Feedback, evaluation and measurement of achievement within the game (e.g., scoring, progress bars, game hints, game levels, etc.)	Assessment, Progress.	(Bedwell *et al.*, 2012)
		User experience, game feedback.	(Avila Pesantez et al. 2017)
		Performance feedback	(Rego et al., 2010)
		Assessment.	(De Lope et al., 2017)
		Feedback/Assessment.	(Lameras *et al.*, 2017)
		Immediate feedback.	(Avila Pesantez et al., 2017)
		Progress monitoring, Performance feedback.	(Wattanasoontorn *et al.*, 2013)
		Efficacy.	(Abdellatif et al., 2018)
		Task Characteristics.	(Shu and Liu, 2019)
Enjoyment	Attractive and fun features of SG context of use (e.g., fantasy elements, mystery, sensory curiosity, characteristic habits or customs, territory.). It covers the process of taking pleasure in playing games.	Fantasy, Mystery, Pieces or Players	(Bedwell *et al.*, 2012)
		Scenario characteristics, Character characteristics, Rewards, Attractive and Fun game features, Reasonable Game Narrative.	(Avila Pesantez et al. 2017)
		Context of use, Narrative, Dedication.	(De Lope et al. 2017)
		Uncertainty, Rewards, Curiosity, Discovery, Narrative.	(Qian and Clark, 2016)
		Fantasy.	(Charsky, 2010)
		Enjoyment, Fantasy, Rewards.	(Shu and Liu, 2019)
		Enjoyment, curiosity, fun.	(Abdellatif et al.,2018)
Gameplay	Refers to rules and the goal makeup of a game and establish criteria for how to win.	Rules/Goals.	(Bedwell *et al.*, 2012)
		Rules, Goals, and Choices.	(Lameras *et al.*, 2017)
		Structure of game levels.	(Avila Pesantez et al. 2017)
		Rules, Clear goals, Scaffolds, Scripted gameplay.	(Qian et al., 2016)
		Rules, Choice.	(Charsky, 2010)
		Gameplay/Rules.	(Djaouti et al., 2011)
		Gameplay.	(De Lope et al., 2017)
		Gameplay relevance, Frequency.	(Shu and Liu, 2019)
		Game type/ Gameplay.	(Abdul Jabbar et al., 2015)

Table2: Common SGCs (CSGCs) matched with SGCS grouped

Proposed CSGCs	Description	SGCs	Source
Activity	The type of activity performed by the player as required by the game. This is the function performed by the player as a response and/or input to the game. Activity types can be physical exertion, physiological or mental.	Activity	(Laamarti et al., 2014)
		Conflict, Control, Interaction (interpersonal), Language/Communication.	(Bedwell *et al.*, 2012)
		Game rules according to players, Communication, Player-centered actions.	(Avila Pesantez et al., 2017)
		Communication, Control, Self-expression Social.	(Qian et al., 2016)
		Autonomy, Control.	(Shu and Liu, 2019)
		Control, Playability.	(Abdellatif et al., 2018)
Environment	The physical or virtual environment that the game takes place in; generally, this includes an installation process and certain configuration parameters. It refers to an environment that merges real and digital worlds, allowing objects from each world to interact in real time.	Real/virtual/mixed, 2D/3D, Location awareness, Online, mobility.	(Laamarti et al., 2014)
		Representation, Location, Sensory Stimuli.	(Bedwell *et al.*, 2012)
		Resources and strengths environment, Geographical location of the player, Interface aesthetics, Immersion.	(Avila Pesantez et al., 2017)
		Augmented reality, Immersion.	(Qian and Clark, 2016)
		Deployment, Hardware architecture.	(De Lope et al., 2017)
		Connectivity (online/offline), Platform, Game interface.	(Wattanasoontorn *et al.*, 2013)
		Game platform.	(Abdul Jabbar et al., 2015)
		Distributed Work, Web-Based.	(Riedel et al., 2011)
		Immersion, Involvement.	(Abdellatif et al., 2018)
Interactivity	The manipulability of a game. It defines whether the interaction of the player with the game is done using traditional interfaces such as keyboard, mouse, or Joystick or using some intelligent interfaces such as a brain interface, eye gaze, movement tracking, and tangible interfaces. How does communication with the game occur?	Interaction style, Modality.	(Laamarti et al., 2014)
		Interaction (equipment).	(Bedwell *et al.*, 2012)
		Interactivity.	(Avila Pesantez et al., 2017)
		Interactivity.	(De Lope et al., 2017)
		Interactivity.	(Qian and Clark, 2016)
		Interaction technology.	(Wattanasoontorn *et al.*, 2013)
		Social interaction competence, User interface.	(Abdellatif et al. 2018)
		Relatedness, Social Interaction.	(Shu and Liu, 2019)
Collaboration	Interpersonal activity that is mediated by technology, which encourages entertaining communal. it depends on whether the game is single or multiplayer. This can be an important criterion to be taken into consideration (role-playing, community collaboration).	Interaction (social).	(Bedwell *et al.*, 2012)
		Single/multiplayer, Social presence.	(Laamarti et al., 2014)
		Collaborative environment, Participation in the game with other family members, Participatory/Collaborative context.	(Avila Pesantez et al., 2017)
		Player interaction.	(De Lope et al., 2017)
		Collaboration and Competition.	(Lameras *et al.*, 2017)
		Collaboration.	(Qian et al., 2016)
		Competitive/collaborative, Number of players.	(Rego et al., 2010)
		Number of players.	(Wattanasoontorn *et al.*, 2013),

Table2: (continued)

Proposed CSGCs	Description	SGCs	Source
Game purpose	It refers to the designed purpose such as message-broadcasting (educative, informative, persuasive, etc.), for training, data exchange or learning objectives such as knowledge acquisition, content understanding, skill acquisition, and motivation.	Purpose.	(Djaouti et al., 2011)
		Game purpose.	(Abdul Jabbar et al., 2015)
		Classification by game purpose.	(Wattanasoontorn *et al.*, 2013)
		Motivating and stimulating learning.	(Avila Pesantez et al., 2017)
Application area	The domain for which the game was created (e.g., health, education, military or public policy, etc.).	Market.	(Djaouti et al., 2011)
		Application area.	(Laamarti et al. 2014)
		Application area.	(De Lope et al.,2017)
		Application area.	(Rego et al. 2010)
		Subject or content areas or skills.	(Abdul Jabbar et al., 2015)
		Application area or domain.	(Wattanasoontorn *et al.*, 2013)
Target audience	The audience for whom the game is intended	Audience (age, type).	(Djaouti, et al., 2011)
		Player age, identity.	(Avila Pesantez et al., 2017)
		Target audience.	(De Lope et al., 2017)
		Target group (decision makers/other employees).	(Riedel et al., 2011)
		Age, gender, users' initial computer skills and users' initial knowledge about e-learning technology.	(Abdellatif, et al., 2018)
		Gender.	(Shu and Liu, 2019)
Technical features	Refers to a set of techniques or procedures which facilitate game development (general, specific to games or specific to SG)	Development methodology.	(De Lope et al.,2017)
		Flexibility of use of the technological tool, Game Support Utility, Application of integration techniques, Validation of input/output data, Technology platform according to game needs.	(Avila Pesantez et al.,, 2017)
		Game technical features.	(Abdul Jabbar et al., 2015)
		Game interface	(Rego, et al., 2010)
		Game engine.	(Wattanasoontorn *et al.*, 2013)

Table2: (continued)

Adaptability

This feature indicates how SG level of difficulty, complexity, challenges, and surprise elements are adjusted to player skills and intended goals. In other terms, it estimates the ability of the game to change to suit different levels of difficulties. Thus, Adaptability is a generic characteristic related to other features such as game complexity (Avila Pesantez et al., 2017), Competition and Goals (Charsky, 2010), and Tasks/Challenges (Lameras et al., 2017). In addition, these features allow evaluating the degree of task complexity in a game matched with the objective intended and the target audience skills. Designers should consider Adaptability characteristics early at the beginning of the design process to select the convenient game mechanics. For

example, designer and domain experts can discuss if the game includes surprises or not and how to adapt them to the player's skills, purpose intended, and domain particularity. In Figure 3, we illustrate some examples of game mechanics that implement the generic Adaptability characteristic. It may also be used as quality criteria to evaluate the SG being designed adaptability.

Assessment

The assessment characteristic gathers the mechanics used to measure the degree of achievement within the game and inform the player of his performance feedback. Evaluation can be shown to the player during the game itself to justify the scores obtained. It includes the scoring, progress bars, game hints, and game levels. The assessment criterion is also used to compare performance among players by the scoring mechanics. It also provides feedback for players to learn from previous actions and adjust accordingly.

Enjoyment

The enjoyment characteristic covers features that define the attractive and fun aspects of the SG, including fantasy elements, mystery, sensory, characteristic habits, or avatars (Charsky, 2010; De Lope et al., 2017; Bedwell et al., 2012; Avila Pesantez and Rivera, 2017). Furthermore, we incorporate role-play and dialogues as curiosity, discovery, storytelling, and narrative features proposed in some papers (Qian and Clark, 2016; Avila Pesantez and Rivera, 2017). According to some works (Abdul Jabbar and Felicia, 2015; Abdellatif et al., 2018; Atkins et al., 2017; Nakatsu et al., 2015) take pleasure in playing games is part of the player motivation and engagement. Moreover, some entertainment components have educational, social, and therapeutic positive effects on player behavior. Mulcahy (2020) confirmed the important role of enjoyment in players' engagement and motivation and how fun influences their positive behaviors. Therefore, they persuaded SG designers and programmers to take into consideration the enjoyment feature in the design phase. Indeed, we suggest Enjoyment as an essential SG feature that can be implemented using some amusing game elements mentioned above. However, in the SG case, it is crucial to balance between serious content and amusement.

CONCLUSION AND FUTURE WORK

The current study aims to determine the main features of SG that support game design and characteristics specification by design stakeholders. The analysis of works surveyed showed that researchers examined, necessarily, game characteristics to conduct their studies. The results of this investigation revealed a redundancy, an overlapping, and a lack of consensus about the game characteristics. For an effective game design based on an accurate understanding of SGCs, we propose 12 generic characteristics related to the game structure and the objective of any SG called CSGCs. These characteristics are Adaptability, Assessment, Enjoyment, Gameplay, Activity, Environment, Interactivity, Collaboration, Game purpose, Application area, Target audience, and Technical features. CSGCs list contributes some way towards enhancing our understanding of SGCs by providing basic characteristics with nomenclature and descriptions. Our CSGCs set helps designers plan the structure of the game being designed in any domain, thanks to the high-level abstraction of each one. It also assists the multidisciplinary game design stakeholders including, domain experts addressing SGCs' complexity and overlapping. Based on a common vocabulary, designers and domain experts could easily collaborate to specify the game elements and matching content requirements and CSGCS. Next, these could be implemented by various game elements and mechanics accordingly to the context of use. The findings might have practical implications for a global approach to SG development including, specification, design, prototyping, and evaluation. This list has great potential in many applications in game design and reusability. Nevertheless, we noted certain limitations

when regrouping some features reported into one generic characteristic. This constraint is due to the relationship between game attributes such as the close interaction within Adaptation, Challenge, and Game complexity. Future research should focus on the practices of our proposed list in the game design process and expose the SG specification levels from the CSGCs selection to the concrete game mechanics implementation. Ultimately, this work may contribute to the understanding of SGCs as a starting point of designing and developing SG in general.

BIBLIOGRAPHY

Abdellatif, A. J., McCollum, B. and McMullan, P. (2018) 'Serious games: Quality characteristics evaluation framework and case study', in 2018 IEEE Integrated STEM Education Conference (ISEC). IEEE, pp. 112–119. doi: 10.1109/ISECon.2018.8340460.

Abdul Jabbar, A. I. and Felicia, P. (2015) 'Gameplay Engagement and Learning in Game-Based Learning: A Systematic Review', Review of Educational Research, 85(4), pp. 740–779. doi: 10.3102/0034654315577210.

Allal-Chérif, O. (2014) 'Using Serious Games To Recruit, Integrate And Train Your Employees: An Exploratory Study Of Practices', European Scientific Journal, ESJ, 10(10). doi: 10.19044/esj.2014.v10n10p%p.

Arnab, S. et al. (2015) 'Mapping learning and game mechanics for serious games analysis', British Journal of Educational Technology, 46(2), pp. 391–411. doi: 10.1111/bjet.12113.

Atkins, A., Wanick, V. and Wills, G. (2017) 'Metrics Feedback Cycle: measuring and improving user engagement in gamified eLearning systems', International Journal of Serious Games, 4(4). doi: 10.17083/ijsg.v4i4.192.

Avila Pesantez, D. and Rivera, L. (2017) 'Approaches for Serious Game Design: A Systematic Literature Review', Computers in Education Journal, 8. Available at: https://www.researchgate.net/publication/321425524_Approaches_for_Serious_Game_Design_A_Systematic_Literature_Review.

Bedwell, W. L. et al. (2012) 'Toward a Taxonomy Linking Game Attributes to Learning: An Empirical Study', Simulation & Gaming, 43(6), pp. 729–760. doi: 10.1177/1046878112439444.

Boughzala, I. and Michel, H. (2016) 'Introduction to the Serious Games, gamification and innovation minitrack', in HICSS-49 : 2016 Hawaii International Conference on System Sciences. IEEE Computer Society, pp. 817–817. doi: 10.1109/HICSS.2016.105.

Boyle, E. A. et al. (2016) 'An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games', Computers & Education, 94, pp. 178–192. doi: 10.1016/j.compedu.2015.11.003.

Carvalho, M. B. et al. (2015) 'An activity theory-based model for serious games analysis and conceptual design', Computers and Education, 87, pp. 166–181. doi: 10.1016/j.compedu.2015.03.023.

Charsky, D. (2010) 'From Edutainment to Serious Games: A Change in the Use of Game Characteristics', Games and Culture, 5(2), pp. 177–198. doi: 10.1177/1555412009354727.

Connolly, T. M. et al. (2012) 'A systematic literature review of empirical evidence on computer games and serious games', Computers & Education, 59(2), pp. 661–686. doi: 10.1016/j.compedu.2012.03.004.

Desurvire, H. and Wiberg, C. (2009) 'Game usability heuristics (PLAY) for evaluating and designing better games: The next iteration', in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), pp. 557–566. doi: 10.1007/978-3-642-02774-1_60.

Deterding, S. et al. (2011) 'From Game Design Elements to Gamefulness: Defining "Gamification"', p. 7.

Djaouti, D., Alvarez, J. and Jessel, J.-P. (2011) 'Classifying Serious Games: the G/P/S model', Handbook of Research on Improving Learning and Motivation through Educational Games: Multidisciplinary Approaches. doi: 10.4018/978-1-60960-495-0.ch006.

Dörner, R. and Göbel, S. (2016) Serious Games Foundations, Concepts and Practice. Springer. Switzerland: Springer. doi: DOI 10.1007/978-3-319-40612-1.

Heintz, S. and Lai-Chong Law, E. (2015) 'Game Elements-Attributes Model: a First Step towards a Structured Comparison of Educational Games', in Proceedings of DiGRA 2015: Diversity of play: Games – Cultures – Identities.

Laamarti, F., Eid, M. and El Saddik, A. (2014) 'An Overview of Serious Games', International Journal of Computer Games Technology, 2014, pp. 1–15. doi: 10.1155/2014/358152.

Lameras, P. et al. (2017) 'Essential features of serious games design in higher education: Linking learning attributes to game mechanics', British Journal of Educational Technology, 48(4), pp. 972–994. doi: 10.1111/bjet.12467.

Lang, D., Chourabi, O. and Boughzala, I. (2014) 'Retour d'expérience sur l'utilisation d'un Serious Game dans l'enseignement des Systèmes d'Information', p. 11.

De Lope, R. P. and Medina-Medina, N. (2017) 'A Comprehensive Taxonomy for Serious Games', Journal of Educational Computing Research, 55(5), pp. 629–672. doi: 10.1177/0735633116681301.

Michael, D. et al. (2005) Serious Games: Games That Educate, Train, and Inform. Cengage Learning. Available at: https://www.researchgate.net/publication/234812017_Serious_Games_Games_That_Educate_Train_and_Inform (Accessed: 28 September 2020).

Mulcahy, R. F., Zainuddin, N. and Russell-Bennett, R. (2020) 'Transformative value and the role of involvement in gamification and serious games for well-being', Journal of Service Management, 32(2), pp. 218–245. doi: 10.1108/JOSM-05-2019-0137.

Nakatsu, R. et al. (2015) 'Entertainment, Culture, and Media Art', in Handbook of Digital Games and Entertainment Technologies. Singapore: Springer Singapore, pp. 1–51. doi: 10.1007/978-981-4560-52-8_16-1.

Perez-Colado, I. J. et al. (2018) ‘Multi-level Game Learning Analytics for Serious Games’, p. 4.

Qian, M. and Clark, K. R. (2016) ‘Game-based Learning and 21st century skills: A review of recent research’, Computers in Human Behavior, 63, pp. 50–58. doi: 10.1016/j.chb.2016.05.023.

Rego, P., Moreira, P. M. and Reis, L. P. (2010) ‘Serious games for rehabilitation: A survey and a classification towards a taxonomy - IEEE Conference Publication’, in. Santiago de Compostela, Spain: IEEE. Available at: https://ieeexplore.ieee.org/document/5556674 (Accessed: 28 September 2020).

Riedel, J. C. K. H. and Hauge, J. B. (2011) ‘State of the art of serious games for business and industry’, in 2011 17th International Conference on Concurrent Enterprising, pp. 1–8. Available at: c:%5CUsers%5CMBA%5CZotero%5Cstorage%5C57LHEWBE%5C6041266.html.

Shu, L. and Liu, M. (2019) ‘Student Engagement in Game-Based Learning: A Literature Review from 2008 to 2018’, Journal of Educational Multimedia and Hypermedia, pp. 193-215 SE–28(2).

Sweetser, P. and Wyeth, P. (2005) ‘GameFlow’, Computers in Entertainment, 3(3), p. 3. doi: 10.1145/1077246.1077253.

Wattanasoontorn, V. et al. (2013) ‘Serious games for health’, Entertainment Computing, 4(4), pp. 231–247. doi: 10.1016/j.entcom.2013.09.002.

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