Balancing Pedagogy, Emotions and Game Design in Serious Game Development

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Abstract—Serious games and game-based learning approaches have been shown to provide effective learning outcomes in various contexts. However, the design of games with educational purposes is not an easy feat, since many aspects must be considered during development: pedagogical theories, learning mechanics, game elements, player experience, and affective, cognitive and behavioral outcomes. The balance of these aspects is one of the greatest challenges both game designers and educators must face in the next few years, especially considering the impact of previously neglected areas, such as the importance of emotions in learning. This work outlines the complexities of this challenge and suggests possible solutions based on high-impact studies to create quality games that excel both in player experience and learning.

Index Terms—serious games, game design, emotional design, game-based learning, human-computer interaction

I. INTRODUCTION

The use and development of games for educational purposes is getting increasing attention in research over the last decade, mainly due to its effectiveness and the emergence of technology assisted education [1]. This interest in games and their pedagogical applications was accelerated by the current pandemic of COVID-19, which made educators transition to new learning practices that are primarily digital, in an attempt to mitigate the pandemic's negative impact on the educational system [2]. Besides gamification [3], there are two main research topics related to games in learning: *i*) the creation of games whose purpose is other than entertainment commonly known as serious games (SG) [4], and *ii*) the redesign of a learning activity by using (serious or entertainment) games, a pedagogical practice known as game-based learning (GBL) [5].

Several studies show the effectiveness of learning and improved cognition through SG and GBL [6]–[8]. However, the exact relationship and causal effects between learning, cognition and the application of SG and GBL is still an open problem, with current methods and tools being deficient in comparing game design elements with particular pedagogical theories [1], [9]. Also, current studies fail in providing generalised results that can support a more comprehensive understanding of SG and GBL's impact [7]. This difficulty in tracing the positive and negative educational impact of specific game structures could be explained by their interdisciplinary nature. Games are composed of multiple elements such as aesthetics, technology, mechanics and story [10], each of them mediating learning through affect, motivation, cognition, and social/cultural foundations [5]. These game foundations are closely related to one another, making the problem of creating a comprehensive view of the impact of game elements in learning even harder. Particularly, affect (i.e. emotions) is closely related with learning and other scenarios where achievement matters [11], as well as cognitive and motivational aspects [12], [13].

The exact nature of game elements themselves has been a topic of discussion, which only increases the complexity of understanding their impact in learning and their relationship with game's foundations. A game element is broadly defined as a fundamental component that integrates a game, being related to its mechanics (e.g. rules, randomness, skills, levels), aesthetics (e.g. user interface, art style, sounds), and narrative (e.g. quests, dialogs, cutscenes) [10].

To design effective SG and GBL practices it is necessary to find the right balance between hedonic (aesthetics, emotions, game elements) and utilitarian (learning) components [14]. However, this balance is also hard to attain; a Delphi interview of academic game design experts stated that one of the greatest challenges of SG design is creating motivational challenges, and not explicitly didactic [15]; another study on the development of SG by teachers working as designers stated that most of them struggled to use basic game elements and combining them into useful learning experiences [16]. This difficulty in bridging educational content and game elements is also present in academic studies: one systematic review shows that in over 658 studies involving SGs and GBL, only 91 presented its underlying learning theory, representing less than 13.68% [17]; another systematic review states that out of 190 studies, 99 (52.10%) explicitly utilizes a pedagogical theory [18].

This lack of a comprehensive view of SG/GBL's game elements and its balance regarding pedagogical, affective, cognitive, motivational and social/cultural foundations is amplified in developing countries. Brazil, in particular, has additional challenges in applying SG/GBL in digital media, since most teachers do not have proper media literacy or feel unprepared to work in a technological environment [19]. The same issues in identifying an integrated view of SG/GBL are also presented

in this country: looking at different systematic reviews focused on the methodological development of SGs, few studies are related explicitly with educational theories [20], [21]; they also lack proper evaluation methods of SG's efficacy [22] or fail to describe theoretical backgrounds for game design practices [23]. None of the frameworks evaluated in these studies explicitly integrates affective or social/cultural foundations into the design or attempts to provide a more direct relationship among game elements and these foundations.

Hence, the main challenge proposed in this work is knowing how to develop high-quality entertaining SG/GBL, considering the relationship between game elements and foundations, being simultaneously effective in terms of learning outcomes and easy to apply in various contexts. Given the multidisciplinary nature of this challenge, several related topics must be tackled by professionals from different backgrounds, from artists, game design experts to psychologists and educators. To address this challenge, this work suggests an integration of various research topics conducted recently in the literature, summarized as follows:

  i) Establish the relationship between specific game elements with pedagogical theories;
  ii) Understand the connection between affect, cognition, motivation and social/cultural foundations in games, and how they influence both player's experience and learning;
  iii) Create an intuitive and effective framework for designing and assessing SG/GBL, based on both empirical practices/industry standards in game design and academic research, that can be used by educators and game designers with various backgrounds.

This integration relates directly with research steps aimed at answering questions like *Which game genre is better suited for fostering a specific skill?*, and *Which game mechanic (jump, shoot, collect, etc) a designer should employ to maximize retention of educational content?*. As simple as they may be, these questions have only recently begun to be even considered in research.

II. RESEARCH TOPICS AND CURRENT DIRECTIONS

Even though studies concerning the creation and application of SG/GBL are not new, the proposed challenge of developing games while fully understanding their foundations and impact on learning is still in its infancy. The subsections below show current research directions that have been explored in order to solve this challenge, as well as highlight their limitations and new paths to be pursued.

A. Mapping game elements with pedagogical theories

The relationship between game elements and pedagogical counterparts is not necessarily a new challenge, but its exact nature is still unclear. The term "game element" itself has been debated among researchers and game designers, with a diverse set of models and frameworks attempting a definition or focusing on some aspects. Even the combination of these elements, which could be used to classify a particular game in a game genre, such as puzzle, action and strategy, is a topic

of debate [24]. Besides, even game mechanics (a fundamental game element) can be recombined and utilized in an emergent manner, giving rise to different game dynamics that can completely alter the gameplay process. The MDA, one of the most known framework in this context, attempts to describe game elements, divided into Mechanics, Dynamics and Aesthetics [25]. However, it presents several limitations [26], which were used as a basis for the development and understanding of SG components and related frameworks [26], [27].

Even though the exact definition of game elements and their combination is unclear, some attempts have been made to link elements and genres to particular educational approaches, like the impact of setting explicit goals versus a goal-free approach in games [28]. The Learning Mechanics and Game Mechanics (LM-GM) model attempts to analyse and discuss SG by linking learning activities with game mechanics [29]. Works connecting game attributes with educational practices in higher education [30] and associating games with player/learner types and behavioral traits [31], [32] have also been identified in the literature. Research has also been developed linking some game genres and learning styles/outcomes [33], but still lack a more systematic approach and further empirical validation, as well as a generally accepted game genre taxonomy that can be applied in the context of SGs.

Current models struggle to provide insights into how one should create an SG using game elements, or guidelines on their optimal combinations. Hence to address the challenge of creating quality SG/GBL, there is a need to conduct research analyzing the incremental effect that certain game elements have in particular learning outcomes, and which element is more attuned to specific pedagogical theories.

B. Understanding the relationship between affect, cognition, motivation and social/cultural foundations

The relationship between SG/GBL outcomes and their impact on learning is yet to be determined since they are composed of cognitive, motivational, affective, and cultural foundations. Some models were proposed considering these multiple processes during learning, like the Integrated Cognitive Affective Model of Learning with the Multimedia (ICALM) [12]. Another proposal is the Integrative Model of Emotion in Game-Based Learning or EmoGBL [34], which accounts for behavior, cognition, and learning as well as emotions related to achievement contexts [11] and their relationship with game elements. However, the processes outlined by EmoGBL are far from being fully mapped and understood.

Particularly, the emotional design of SG/GBL has been recently being studied in terms of color, shape, dimension and anthropomorphism [35], [36]. However, research connecting game elements to social/cultural perspectives and their relationship with psychological traits presented by particular players is still incipient. Another issue related to emotional design and SG/GBL is to identify the exact nature and temporal disposition of emotions being evoked in games: studies concerning the relationships and interactions between emotions over time during a multimedia learning experience

just recently began to be proposed. One study that goes into this direction discovered that emotions such as boredom and frustration have a delayed effect in learning and overall game experience [37]. To address the proposed challenge, future research should be based on an integrated model of learning processes, such as EmoGBL, while being adaptable enough to account for individual player's psychological traits and cultural differences.

C. Creating intuitive guidelines for SG/GBL development

Game design research and design research as a whole are based on both empirical and theoretical foundations, where typically the understanding of a problem is achieved by building and testing a designed solution [38]. Due to this dual nature, several conferences and organizations related to games attempt to bridge industry practices with academic research, like the IEEE Conference on Games[1], and the Brazilian SBGAMES[2]. However, these industry-academic tracks are more focused on academic approaches to industry-related problems than on industry practices that could be utilized by researchers, designers and teachers alike to develop better SGs/GBL practices. This second approach must be sought, since many game design practices are first presented by companies and game studios, rather than academia. Due to this "industry-first" nature, few educators present all the required skills to create quality SGs [39]. This scenario brings forth the need for a long-term collaboration among industry experts, teachers and academic researchers to i) exchange empirical practices among game designers and educators; ii) promote the exchange of assets (aesthetics, sound effects, code) between game studios and research institutions; and iii) promote joint studies and partnerships with selected game studios.

Thus, the challenge of how to create SG/GBL relies not only on structuring game elements and their foundations but also on creating intuitive design processes that can support educators. Design frameworks that are based on simple models (e.g. MDA) or present some concern for the designer/educator experience must be sought for researchers and practitioners alike. Even though various guidelines towards the creation of SG/GBL have been proposed, little is known about their acceptance and usage from practitioners/academics other than the ones that created these guidelines.

III. Actions and their Assessment over time

To address the proposed challenge, some actions and principles can be used to guide future research:

i) proposal and usage of a unified taxonomy of game genre and game elements that can be used by game designers and educators alike;

ii) creation of a unified open repository of empirical evidence concerning the use of game elements and their incremental impact on all SG/GBL's foundations (cognitive, motivational, affective, and cultural);

[1]https://ieee-cog.org/
[2]https://www.sbgames.org/

iii) providing easy-to-use tools, models and frameworks that can support educators in game design activities;

iv) validating SG/GBL design through empirical evidence and feedback of a series of stakeholders: educators, game design experts and players.

The follow-up to evaluate these initiatives involves i) periodically assessing game research and gray literature (game releases, blog posts from industry experts) in an attempt to create and update an unified genre taxonomy; ii) monitoring the number of studies in peer-reviewed journals and conferences that employ empirical research to propose and/or validate SG/GBL's design, integrating game foundations and elements; similarly, studying the gray literature looking for game design elements and their impact on aforementioned foundations; iii) monitoring the acceptance of design artifacts both in academia and industry, through usage metrics and heuristic evaluations, as well as monitoring research that considers the impact of specific game elements in learning environments; ideally, these should be summarized through reviews and meta-analytic studies; and iv) periodically organizing workshops between academics and game designers, along with conducting industry censuses related to the usage of game design artifacts is also critical to identify new trends and integrate them into SG/GBL design appropriately

IV. Final Remarks

Even though the use and efficacy of serious or entertainment games in learning processes have been established in the literature, there is a knowledge gap regarding the relationship between specific game elements and all their potential outcomes in learning. Based on several systematic reviews and recent studies, this work states that the process of creating of SG/GBL considering the integration of game elements (e.g. mechanics, aesthetics, narrative), pedagogy, and game foundations (affective, cognitive, cultural, motivational) is a major challenge in game research during the next decades.

Various issues must be solved to address this challenge: offering a widely accepted connection between pedagogical theories and game elements; understanding games outcomes and their relationship with learning, particularly considering the importance of emotions; proposing intuitive tools for game development drawn from the game industry. The progress of this challenge must be evaluated by monitoring studies related to game foundations, based on empirical evidence and/or industry collaboration, in the form of recurrent censuses, workshops, interviews and grounded research. Future research should also propose and integrate empirical results in a unified repository to inform game design practices and their influence on learning.

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