# *Designing an application to support game-based learning:*

## *gathering functional requirements from a qualitative approach*

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*Abstract* — **This article seeks to contribute to the deepening of knowledge when designing game-based learning activities. During the design process, the specification stage is particularly relevant, being the functional requirements an important component of this process. Qualitative approaches to its gathering have gained relevance and aroused interest within the scientific community, being of most importance to describe studies that use these methodologies. This study describes the gathering of functional requirements, from a qualitative approach, to design an application for cataloging and evaluating educational games. A focus group of eight experts was set up; the functional requirements of the application were gathered according to the Communicative Design Paradigm, aiming to identify the indicators of the proposed application, using the Octalysis gamification framework.**

***Keywords — educational games; game-based learning; gamification; functional requirements.***

## I. INTRODUCTION

One of the advantages of using digital educational games is related to a good receptiveness from younger people, as they often already bring gameplaying practices from home. Playing video games is quite attractive for most teenagers and young people [1]. Associating an enjoyable activity with the school context, such as the introduction of Game-Based Learning (GBL) environments, may increase student motivation, promote intellectual development and facilitate learning in various fields [1], [2]. By associating a playful component, enriched by visual and hearing tools, all recognized for having a great influence on cognition [3], the student easily captures the topics addressed by the game. Thus, when articulated with the most traditional methodologies, educational games seem to favor a more effective transmission and produce excellent results in essential learning [4]. On the other hand, games may also bring a relational approach, favoring the relationships between students and between student and teacher [5].

Through the game, the student is invited to make decisions and solve problems; he/she faces several and increasing challenges that he may overcome through trial-and-error mechanisms. From another perspective, Serious Games (SG) allow the player to connect with the situation, which may lead the player to assume a position of self-criticism. The advantages of applying GLB in education are also centered in the learning experience (of being more active), of the immediate feedback, of provoking behavioral changes and of being applicable in varied contexts [6].

However, in order that the GBL benefits can be recognized, it is important that joint formal evaluation techniques are available to bring objective data towards game selection. The evaluation of digital educational games is one of the main instigations of the present study and integrates the dimensions: 'Player Motivation' [7], 'User Experience' [8], [9] and 'Learning acquired' by playing the game [10] (Fig. 1).

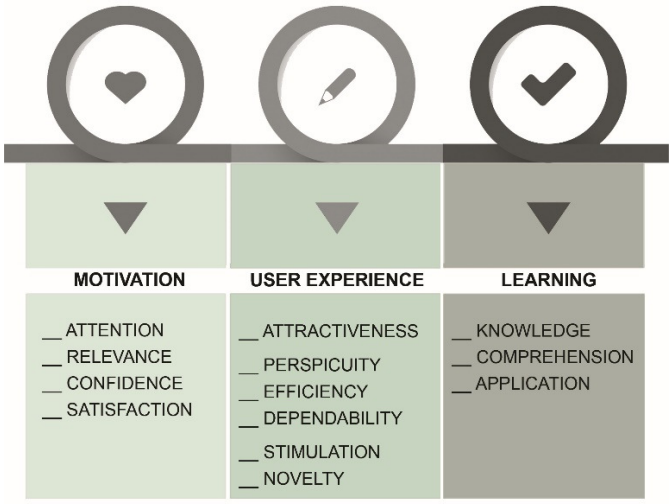


Figure 1. Evaluation indicators for digital games

On the other hand, once the advantages of using GBL as a teaching strategy are perceived, it is important to improve the conditions given to teachers in the game selection process. Thus, the creation of a digital application to support the serialization, cataloging and evaluation of educational games, based on practical and real cases and supported by evaluation models recognized by the scientific community, may make the process of choosing the game more robust.

As such, to strengthen the design of the model, the main players in the educational system were inquired– students and teachers (through sessions of the Unlove [11] and Carmen Sandiego games) and experts (in group dynamics that enabled

the identification of requirements for the development of the digital application). Finally, in order to motivate future users-teachers to use the digital application, one can see the importance of taking into account in its genesis, the gamification principles.

## II. BACKGROUND

### A. Evaluation of digital educational games

The classification of digital games can be based on multiple categories: according to the end goal of the game, the definition of goals, the interaction that may exist between the game and the player (or multiple players), the unilateral or multilateral competition between several players, or also through collaborative action between the users [12]. It is also important to determine how to score, how to navigate in the resource, and to integrate external and internal information; these are also relevant categories for game classification [13].

In order to provide focus to digital educational games and, to acknowledge the benefits of their use in the school context, it is important that there are joint techniques of formal evaluation that can bring objective data towards the game selection process. In this regard, it is important to mention two recent contributions to the area under study: the first – a proposal for classification of digital and non-digital games used in the area of requirement's engineering [14]. Also contributing to a general theoretical view, some authors refer to evaluation methods for simulation games [15].

### B. Serious-Games and Game-Based Learning

There are several situations in which the terms Serious Games (SG) and Game-Based-Learning (GBL) intersect in the literature when we focus on the theme of learning by using activities with a playful component. It is true that the concept of play predates the digital age; it emerges as an extension to playful activity and not with digital technology [16]. The truth is that humanity has always had the attraction to enjoy and participate in games, whether analog or digital, which refers to new adaptation approaches [6]. With regard to digital games, literature labels these technological means as educational games or SG [17].

The acronym SG, popularized in 2002 by Ben Sawyer, refers to computer applications developed by programmers following the study of researchers, in conjunction with industrialists, on how video games may be used outside the context of fun [18]. This idea of associating games with serious aspects is reinforced by [19] who advocate that games are not primarily aimed at fun, entertainment and pleasure. It is not disputed that SG bring joy and well-being to the user, but other main intentions are raised in that approach such as to educate, train or bring knowledge alluding to a particular area of study [20]. In this context, the integration of pedagogical scenarios in the game becomes the purpose of the SG, reporting to a digital application that combines the playful designs of the game with serious aspects of teaching and learning, in a coherent way and according to specific rules, but not exhaustively. The SG is perceived as the instrument that improved the concept of educating in an active and playful way [17] and, in the content acquisition, may be seen as a tool for replacing practical exercises; it is richer than puzzles, role-playing games and simulators [20].

To transform the features of an SG in an effective tool in the educational context, authors recall the importance of learning and motivational theories that are inherent to GBL, recognizing the pedagogical potential of the game [21]. The term GBL refers to the application of SG to support the learning of students [17], [20]. Game-based learning environments are increasingly being used in the school context; first, because its advantages in academic results are recognized; second, because there is a greater motivation in students [22].

GBL may be understood as a subset of SG in which games are tools that contribute to an immersive environment where learning becomes attractive and is aimed at a specific curriculum goal [20]. To consolidate this vision, it is important to implement self-regulatory measures through self-assessment reports of students and relate these variables with the performance results obtained in GBL. In addition, assessing motivation and referencing key indicators of motivation in GBL becomes urgent [22].

### C. Clarification of the Gamification concept

It is undeniable that there is a distinction between GBL and Gamification. While the former refers to a full game context, the second enables the implementation of strategies and activities that seek to use tools associated with the game, but in a 'non-game' environment. The term Gamification appears, for the first time, in scientific publications in 2008 [23] and refers to actions similar to those practiced by the players. Although game design elements and game mechanics are used, actions take place in a context other than that of the game [23]-[26]. Identified as elements present in games, are the characters/avatars, the narratives, the challenges, the rewards, the scoring and return/feedback system, the difficulty levels, as well as the tools that enable the interaction between the resource and the user such as buttons or controls. The same authors indicate that all these elements and mechanics are summarized to the categories – character, competition and rules of the game – and that these are the classes that may be mirrored in gamification contexts and have a straight effect on learning and motivation.

The main objective of gamification is to support and motivate users to perform a set of tasks [23].

Some authors associate the term Gamification with the use of game mechanics to learn in a fun and enjoyable way [26] – an idea shared and complemented by Chou [27, p. 8], when he states that "gamification is the craft of deriving fun and engaging elements found typically in games and thoughtfully applying them to real-world or productive activities." Thus, inherent to the game, the notion of problem-solving is present as a challenge to be overcome, but with a playful and entertaining character; it is important that this premise is transposed to gamified activities.

### D. YuKai Chou's Octalysis framework in the gamification process

Chou [27] also, demonstrated through the theoretical-methodological model Octalysis that gamification goes beyond points, medals and rankings. The Octalysis framework helps to unravel the motivational impulses obtained through gamified activities. This understanding may be converted into changes and bring transformations in the developed practices, making them more enriched [28]. Chou's [27] tool is developed into

eight cores (Fig.2). The importance given to each segment will expand or contract its side of the octagon [27], [29].

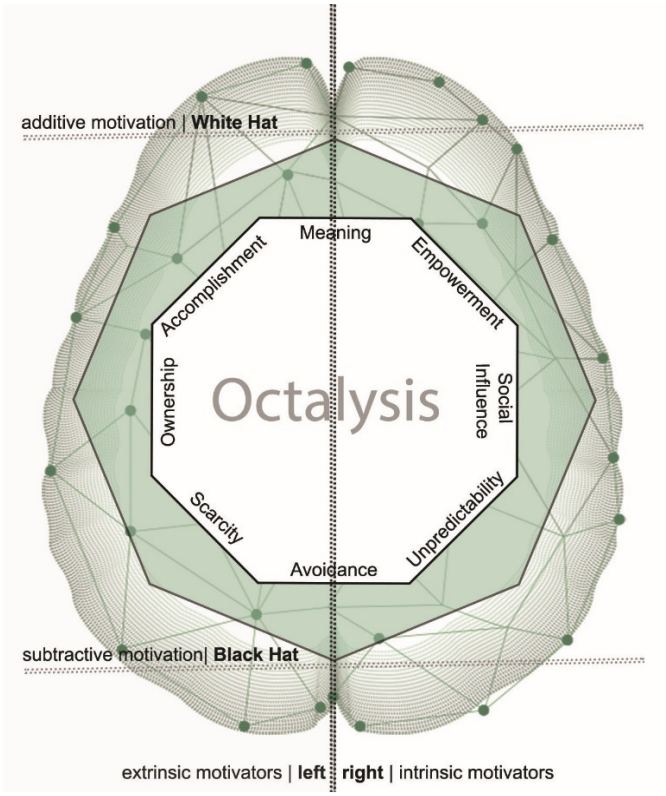


Figure 2. Framework Octalysis (adapted from [27])

(1) 'Epic meaning & calling' – it is about assigning tasks or functions to the user so that they feel part of a mission where he will feel valued. (2) 'Development & accomplishment' – it implies winning, awarding rewards through challenges that keep users engaged. (3) 'Empowerment of creativity & feedback' – refers to the assignment of skills that may increase the user's personal fulfillment. (4) 'Social influence & relatedness' – the interaction with other people (or simply knowing what they like, think or feel) may engage the user. (5) 'Unpredictability & curiosity' – the discovery piques the user's interest, which implies that not everything should be controlled and regulated. (6) 'Loss & avoidance' – presupposes events that should be avoided because they cause unpleasant situations and with negative consequences. (7) 'Scarcity & impatience' – presupposes the appreciation of a particular activity by the user because it is associated with a good of limited access. (8) 'Ownership & possession' – these are activities that enable the user to acquire something [27].

The nature of the different cores differs by their approach to the axis: (i) upper horizontal – White Hat (additive motivation), when it comes to rewards or pleasant feelings; or lower horizontal – Black Hat (subtractive motivation), when we report for feelings of fear, uncertainties or anxiety [27], [29]; (ii) right vertical – the right side of the brain, usually associated with creativity and socialization, calls for intrinsic motivation (inner strength); left vertical – the left side of the brain, usually related to logic, analytical thinking, concerns extrinsic motivation and the need to achieve a goal [27].

## III. PARTICIPATORY DESIGN

### A. *Multidisciplinary team*

From the point of view of the research objectives, the methodological design of this study is strongly influenced by the approaches of Educational Design Research [30].

To answer the starting question "How to characterize a proposal for a digital application to catalog and evaluate an educational game?" a multidisciplinary team of experts was created aiming at enriching the domain under study and at bringing their empirical knowledge to the design of the model. The focus group was created to inquiry the experts, hear and collet their opinions on what they feel and think about the object under study [31]. It is important to establish a dialogue between those who present the prototype and those who will use the digital application. This participatory design approach was used to increase the degree of acceptance of the digital proposal. [32].

The focus group was composed of eight experts from different subjects (such as Geography, Sociology and STEAM – Science, Technology, Engineering, Arts and Mathematics). Combining teams with different backgrounds increased the chances of obtaining a more distinctive digital application, since each element examined the problem in a different perspective [33]. The selection of the participants was ensured by a process in which inclusion criteria allowed the creation of a team's cohesion dynamic. Similar characteristics of the participants, allowed the identification of trends and patterns in the perceptions' analysis that derived from the group discussion [31].

### B. *A research roadmap based on a Communicative Design Paradigm*

Gustafson et al [34] refer to different classification approaches to the processes and models of instructional design and propose the creation of a conceptual framework that includes four design paradigms – Instrumental, Communicative, Pragmatic and Artistic. In the Communicative Design Paradigm (CDP), the consensus among the professionals involved in the process of developing an educational solution prevails [34]. This is a broader and more enriched view than the design structure of the model Analysis, Design, Development, Implementation and Evaluation – ADDIE [35].

In this study, throughout the six stages of the CDP, the dynamics were established among the experts of the focus group and received input from the game sessions with the students and teachers, as seen in Figure 3. In Educational Design Research [30] it is common to use multiple sources of data, particularly considering the need to enquire end-users and experts. The Focus Group was used to, based on the opinions of the experts, gather the requirements for the model of the digital application to be implemented, considering its main objective: to be used as a gamified resource. This exchange of ideas among all enabled the consensual improvement of the proposal under discussion, as detailed bellow, following the procedures of the CDP framework.

In the 1st stage – PLATFORM OF IDEAS, the focus group participated in an online explanatory session, defining the

problem, identifying restrictions and fundamental assumptions, demonstrating existing digital solutions (www.cokitos.pt, www.digipuzzle.net, www.1001jogos.pt), and attempting to conceptualize the problem.

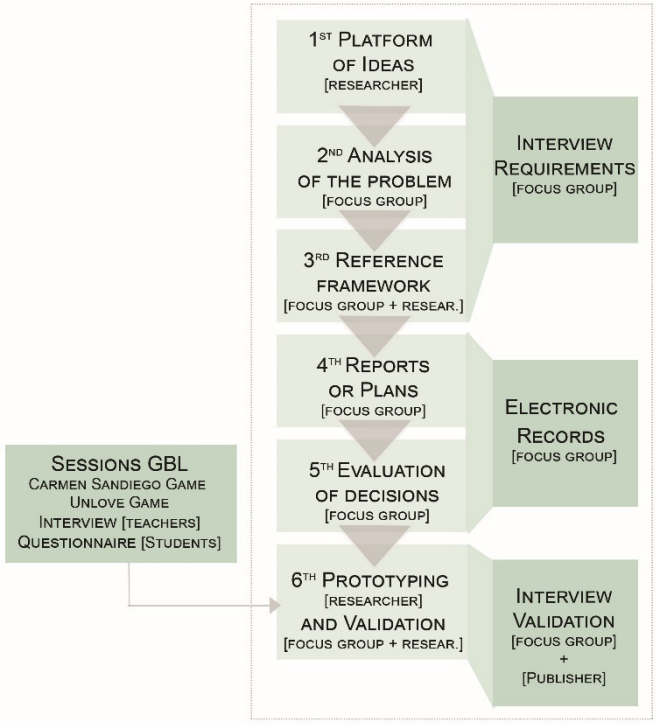


Figure 3. Application of the Framework of the CDP (adapted from [34])

In the 2nd and 3rd stage – ANALYSIS OF THE PROBLEM and REFERENCE FRAMEWORK – the expert team analyzed the problem and created a framework of reference. At this stage, the researcher motivated the team to discuss and express their opinions. The development of different solution scenarios was encouraged.

The experts were encouraged to share their views in a forum of the Learning Management System (LMS) platform of the institution under study, and, working in pairs, were invited to create mental maps representing the requirements (domains and indicators) they considered that should be included in the application (4th stage – development of REPORTS OR PLANS).

After sharing the electronic records on the LMS platform, moments of discussion and validation of mental maps took place among the experts (5th stage – EVALUATION OF DECISIONS of other team members). After analyzing the mental maps, the researcher asked the pairs of specialists to clarify some domains and indicators for the prototype they had suggested.

The current stage of this study is the 6th stage – PROTOTYPING AND VALIDATION of the proposed application. Prototyping allows a better understanding of the problem and, consequently, a better definition of its specifications. After prototyping the digital solution, the researcher will work with the group of experts, and also with a national publisher. This stage will promote the discussion and creation of new ideas until a coherent proposal is obtained.

## IV. SPECIFICATION OF REQUIREMENTS

The analysis of the requirements for the design of the digital application model was based on the mind maps and interactions of the focus group experts on the LMS platform (Cf. III B.). The listed indicators were grouped into six main domains: (1) Game; (2) News panel; (3) Interaction; (4) User; (5) Ranking; and (6) Language.

The domain (1) GAME consists of the indicators: (1a) subject area (science, mathematics, technologies, languages, visual arts, social sciences and humanities, sport, citizenship and development, sexuality education, religions); (1b) Specifications (synopsis, re lease date, degree of interactivity, free of charge, usage tips, mobile or desktop format, tutorial, rules, operating system type, technical requirements such as memory / disk space, accessibility, related games); (1c) Level of education of the target audience (Preschool, 1st, 2nd and 3rd cycle of basic education, secondary school); (1d) Type (quiz, strategy, memory/reasoning, simulator, board, family, puzzles, mime, crossword, motricity, coloring, letter soup); (1e) Number of players (single, multiplayer); (1f) Target audience age group (3-4 years, 5-6 years, etc., i.e. two-year grouped levels up to 18 years); (1g) Ordering (most played, newest, most popular, alphabetically A-Z and Z-A); (1h) Search (by game name, subject area, teaching cycle, release date); (1h) Online store (with access to game providers); (1i) Evaluation survey (according to the dimensions, motivation, user experience and learning).

For the domain (2) NEWS PANEL, the following indicators are presented: (2a) News/Updates with the possibility for the user to insert comments (launch of new games; updates of existing games, sharing of experiences by users; key users, promotions, events related to the games, websites of interest); (2b) Non-educational games; (2c) Scientific publications in the GBL area; (2d) FAQs; (2e) Top 10 games.

Indicators for the domain (3) INTERACTION are: (3a) Public chat; (3b) Discussion forum; (3c) Pairing (suggestion of users with a similar profile for Private Chat); (3d) Platform notifications to the user (score status).

For the domain (4) USER, the following indicators are listed: (4a) Identification (name, email, username, avatar construction / profile picture, age, gender); (4b) Interests (areas of interest, subject group, education levels, favorite games, followers and following); (4c) Status (beginner / junior / senior / expert user rating resulting from their interaction on the platform, badges awarded as for example the user of the month / the user who publishes the most / the user who shares the most, prizes such as discounts on the purchase of games or tickets for events on games / unlocking content / custom settings of the application).

Regarding the domain (5) RANKING on the game, the indicators point to: (5a) Scale for each dimension under study (motivation, user experience, learning); (5b) Overall scale (not recommended / reasonable / optimal / good / excellent based on the overall assessment of the three dimensions under study); (5c) Platform interaction scale (most rated game, most commented game); (5d) Scale of emotion regarding the effectiveness of the game applied in the classroom (went well / badly, liked / did not like).

Regarding the domain (6) LANGUAGE, the indicators listed concern the five (6a) languages used in the application (Portuguese, English, Spanish, French and Spanish).

## V. CONCLUSIONS AND FUTURE WORK

The constitution of multidisciplinary teams involving professionals in different areas such as pedagogy, design, technology and project management, allows the discussion and validation of new, relevant and necessary knowledge in the development of educational projects. Thus, building of an enriched vision of the problem will not rely only on a single professional; the focus is not only on the scientific area of each team member but also on their experiences, as each one may bring his opinions and perceptions about the problem to be solved and the solution to be developed. During the study described in this article interaction and communication processes were valued: social aspects among experts from different segments were highlighted, enabling the gathering of the functional requirements from a qualitative approach.

The requirements presented by the focus group refer to a digital application for cataloging and evaluating educational games, that follows the principles of 'gamification' seeking to motivate the user for its use. From the raised proposal we crossed the Octalysis model and its cores: 'Accomplishment' with the assignment of points and leaderboards; 'Ownership' with obtaining badges from several families; 'Meaning' with better-performing user groups and differentiated task assignment; 'Empowerment' with application editing and configuration privileges; 'Social Influence' with the inclusion of followers and verification of their status resulting from their interactions; 'Unpredictability' with the award of unexpected prizes; 'Avoidance' with notifications to the user about the possible loss of points due to the absence of an interaction; 'Scarcity' when the user is informed that he/she has earned points but that obtaining them is conditional on performing a task.

In the future, and after the prototyping of the application, an interview will be applied – Validation – to the experts and to a national editorial group, aiming to clarify their opinions and perceptions in the face of the prototype mockups, thus complying with the 6th and last step of the communicative design paradigm framework.

## REFERENCES


[1] A. Carvalho, N. Zagalo, and I. Araujo, "From Games Played by Secondary Students to a Gamification Framework," *Soc. Inf. Technol. Teach. Educ. Int. Conf.*, vol. 2015, no. 1, pp. 737–744, 2015.

[2] S. Syal and J. L. Nietfeld, "The impact of trace data and motivational self-reports in a game-based learning environment," *Comput. Educ.*, vol. 157, no. October 2019, p. 103978, 2020.

[3] M. Matias, V. Heemann, and N. Santos, "Aspectos cognitivos da interação humano-computador multimídia," in *Workshop sobre Fatores Humanos em Sistemas Computacionais*, 2000, vol. 3, pp. 22–32.

[4] P. S. Lisenbee and C. M. Ford, "Engaging Students in Traditional and Digital Storytelling to Make Connections Between Pedagogy and Children's Experiences," *Early Child. Educ. J.*, vol. 46, no. 1, pp. 129–139, 2018.

[5] J. Kirriemuir and A. Mcfarlane, "Literature Review in Games and Learning," *Futurelab*, vol. 3, no. 2, p. 39, 2004.

[6] B. H. Yousefi and H. Mirkhezri, "Toward A Game-based Learning Platform : A Comparative Conceptual Framework for Serious Games," *Proc. 2019 Int. Serious Games Symp. ISGS 2019*, pp. 74–80, 2019.

[7] J. M. Keller, *Motivational Design for Learning and Performance: The ARCS Model Approach*. New York: Springer-Verlag New York Inc., 2010.

[8] M. Reis and A. Almeida, "Measurement of the User eXperience. Educational games Unlove and Carmen Sandiego.," in *Encontro Ciência 2020 - 2, 3 e 4 de novembro de 2020, Lisboa, Portugal*, 2020.

[9] M. P. Cota, J. Thomaschewski, M. Schrepp, and R. Gonçalves, "Efficient measurement of the user experience. A Portuguese version," *Procedia Comput. Sci.*, vol. 27, no. 34, pp. 491–498, 2014.

[10] B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H. Hill, and D. Krathwohl, *Taxonomy of educational objectives: Handbook I: Cognitive domain*. New York: David McKa, 1956.

[11] A. M. P. Almeida, J. Lima, M. J. Pereira, and M. Silva, "UNLOVE: A Digital Game for Gender-Based Violence Prevention and Awareness," in *Proceedings of the International Conference on Gender Research*, 2018, pp. 342–350.

[12] T. Fullerton, *Game Design Workshop: a playcentric approach to creating innovative games*, 2nd ed. Amsterdan: Elsevier, 2008.

[13] B. Schmitz, R. Klemke, and M. Specht, "Effects of mobile gaming patterns on learning outcomes: A literature review," *Int. J. Technol. Enhanc. Learn.*, vol. 4, no. 5–6, pp. 345–358, 2012.

[14] M. T. Soo and H. Aris, "Game-Based Learning in Requirements Engineering: An Overview," *2018 IEEE Conf. e-Learning, e-Management e-Services, IC3e 2018*, pp. 46–51, 2019.

[15] N. D. Faizan, A. Löffler, R. Heininger, M. Utesch, and H. Krcmar, "Evaluation Methods for the Effective Assessment of Simulation Games," in *21 International Conference on Interactive Collaborative Learning*, 2018, pp. 626–637.

[16] N. Zagalo, *Videojogos em Portugal - História, Tecnologia e Arte*. Lisboa: FCA, 2013.

[17] Y. L. Tsai and C. C. Tsai, "A meta-analysis of research on digital game-based science learning," *J. Comput. Assist. Learn.*, vol. 36, no. 3, pp. 280–294, 2020.

[18] D. Ahrens, "Serious Games – A New Perspective on Workbased Learning," *Procedia - Soc. Behav. Sci.*, vol. 204, no. November 2014, pp. 277–281, 2015.

[19] D. R. Michael and S. L. Chen, "Serious games: Games that educate, train, and inform." 2005.

[20] H. Al Fatta, Z. Maksom, and M. H. Zakaria, "Game-based learning and gamification: Searching for definitions," *Int. J. Simul. Syst. Sci. Technol.*, vol. 19, no. 6, pp. 41.1-41.5, 2018.

[21] A. Yusoff, R. Crowder, L. Gilbert, and G. Wills, "A conceptual framework for serious games," *Proc. - 2009 9th IEEE Int. Conf. Adv. Learn. Technol. ICALT 2009*, pp. 21–23, 2009.

[22] S. Syal and J. L. Nietfeld, "The impact of trace data and motivational self-reports in a game-based learning environment," *Comput. Educ.*, vol. 157, no. October 2019, p. 103978, 2020.

[23] Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness," *Proc. 15th Int. Acad. MindTrek Conf. Envisioning Futur. Media Environ. - MindTrek '11*, no. March 2014, p. 9, 2011.

[24] A. Domínguez, J. Saenz-De-Navarrete, L. De-Marcos, L. Fernández-Sanz, C. Pagés, and J. J. Martínez-Herráiz, "Gamifying learning experiences: Practical implications and outcomes," *Comput. Educ.*, vol. 63, pp. 380–392, 2013.

[25] L. M. Fadel, V. R. Ulbricht, C. R. Batista, and T. Vanzin, "Design motivacional no processo de gamificação de conteúdos para objetos de aprendizagem: contribuições do modelo ARCS," in *Gamificação na educação*, São Paulo: Pimenta Cultural, 2014, p. 300.

[26] K. M. Kapp, "The Gamification of Learning and Instruction: Game-Based Methods And Strategies For Training And Education," *Conjectura Filos. Educ*, vol. 18, no. 1, pp. 201–206, 2012.

[27] Y. Chou, *Actionable Gamification - beyond points, badges and leaderboards.* CA: Octalysis Media, 2016.

[28] S. Oliveira and M. Cruz, "The gamification octalysis framework within the primary english teaching process: The quest for a transformative classroom," *Rev. Lusofona Educ.*, vol. 41, no. 41, pp. 63–82, 2018.

[29] M. Ferreira, G. Miranda, and L. Morgado, “Análise das funcionalidades de gamificação nos ambientes de aprendizagem Classcraft e Moodle à luz da framework Octalysis,” *4º Encontro sobre jogos e mobile learning*, Coimbra, pp. 117–130, 2018.

[30] J. van den Akker, B. Bannan, A. E. Kelly, N. Nieveen, and T. Plomp, *Educational Design Research - Part A: An* introduction. Enshede: SLO - Netherlands Institute for cuurriculum development, 2013.

[31] R. A. Krueger and M. A. Casey, *Focus Groups: A Practical Guide for Applied Research*, 5.ª. London: Sage Publication - International Educational and Professional Publisher, 2015.

[32] B. Shneiderman, Designing the User Interface: Strategies for Effective Human- Computer Interaction, 3.a. Addison-Wesley, 1998.

[33] IDEO, “HCD Human Centered Design: Kit de ferramentas,” IDEO, EUA, 2009.

[34] K. Gustafson, I. Visscher-Voerman, and T. Plomp, “Educational Design and Development: An Overview of Paradigms,” in Design Approaches and Tools in Education and Training, B. V. Springer - Science+Business Media, Ed. Kluwer Academic Publishers, 1999, pp. 15–29.

[35] I. Visscher-Voerman and K. L. Gustafson, “Paradigms in the Theory and Practice of Education and Training Design,” Educational Technology Research and Development, pp. 52(2), 69–91, 2004.