Proposal for a Participatory Methodology for the Creation of Serious Games

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Abstract: We are facing a new generation of students, who are not only looking for theoretical knowledge, but also want learning to be practical, interesting, and fun. They request didactic techniques that allow them to have a more prominent role in their learning, models that are not focused on teaching, but on learning. They are students with different characteristics because they were born in the digital age. Technology has changed the way they relate to the world. They are not comfortable with respect to traditional models and try to incorporate new technologies into all aspects of their lives. Within the educational field, new technologies are seen as a tool that facilitates learning and develops skills in students. From this perspective, the development of simulators and serious games are now used as a strategy to facilitate learning. The advantages of using a serious game seem evident, they help develop critical thinking, encourage creativity, increase problem-solving skills, increase retention, among other benefits. However, when games are not well designed, they lose both their appeal and their playful essence. One reason for these problems is the absence of the application of any design methodology, and that many of these problems come from the requirements definition phase. Specifically, most of the problems occur in the game design phase, where there is a deficiency in the writing of the requirements requested by the teachers. When the requirements are vague, or ambiguous, experts in the development area are unable to interpret the interaction design, the game mechanics, or the way in which users will interact with the software. This article aims to discuss the specifications and requirements that instructional designers and developers should address before migrating to project development, implementation, or evaluation. This article is important because it analyzes the need to establish clear requirements and objectives that will facilitate the creation of serious games in education.

Keywords: Serious games, Higher education, Educational innovation, Game-Based learning, Simulators, Virtual learning

1. Introduction

In recent years we have been experiencing a technological revolution that has changed our lifestyles and modifies our paradigms. Social networks, cloud computing, automation, artificial intelligence, IoT, are some of the information and communication technologies that have transformed our way of perceiving the world. These innovations have transformed the paradigms of societies, changed the skills and competencies demanded by employers, and renovated the way knowledge is created, transmitted, and assimilated. In addition, the younger generations have different characteristics. On the one hand, they are digital natives, and they feel more comfortable with the use of technology (Monaco and Martin, 2007); and on the other hand, they prefer to have a more prominent role in their learning. Methodologies that only allow information transfer in one direction make them uncomfortable (Kiili, 2005).

Within the educational field, Information and Communication Technologies (ICTs) are seen as tools that can promote learning opportunities and develop skills in students (Gros, 2016). Many examples of the use of ICTs can be observed in educational platforms and virtual environments. Specifically, the use of Serious Games (SGs) and simulators has been one of the preferred options for students in the classroom, it has been shown that the participation of learners in these games generates changes in their attitudes, beliefs, or behaviours (Tilvawala, 2019). From this perspective, SGs are now used as a strategy to support learning. Different areas of study use this resource, medicine (Graafland, Schraagen and Schijven, 2012), logistics (Pacheco-Velazquez and Aguilar-Avalo, 2019), military training (Samčović, 2018), nursing (Tan, Lau and Liaw, 2017), among others.

One of its great advantages of using SGs is the creation of motivational factors that have significant learning for students (Naul and Liu, 2020) (Meij, Veldkamp and Leemkuil, 2020). On the other hand, there are authors who affirm that SGs help students to develop critical thinking skills (Madani, Pierce and Mirchi, 2017), improve retention (Bergeron, 2008), increase creativity (Riedel & Hauge, 2011), develop problem-solving skills and decision making (Pacheco-Velazquez, 2022).

Although the benefits of playing serious games seem obvious, not all serious games work the same way. Some researchers claim that games that are not well designed lose both their appeal and their playful essence (Ravyse et al., 2017). Some studies point out that this happens because not all serious games are the result of applying some design methodology, and that many of these problems come from the requirements definition phase (Carrion et al., 2017). Taking care of the design phase in the creation of a serious game is one of the most important points that developers and academics should consider. This stage is fundamental because the characteristics of the game, the interaction of the players, the learning objectives, and the creation of the databases are defined in it.

This article aims to establish the steps that must be followed to achieve an efficient development design for serious games and achieve the purposes for which they have been designed.

2.   Literature Review

A general statement is that people love to play games. A game is represented by a set of rules that establish norms for the interaction and behavior of the players and offer an identifiable result. With the new technological trends, digital games have achieved enormous success. It is not just about the graphic elements, most of the successful games also have sophisticated design methodologies that emotionally engage the players (Lugrin et al., 2013).

The definition of a SGs is a digital game created with the intention to entertain and to achieve at least one additional goal (e.g., learning or health) (Dörner et al., 2016). This type of game has objectives that are beyond the playful element, if in addition to being fun and entertaining, they must also provide teaching, then we are talking about educational games. Carrion et al. (2017) points out that many serious games are not well designed in their initial phase, and at the end of the project, teachers and developers realize that the game does not meet the pedagogical objectives, they add that although there are a series of methodologies specifics for videogames, the number of methodologies proposed for the design of SGs is limited.

Nadalski et al. (2008) describe a five-phase methodology for developing serious games which they call EMERGO. In the first phase, the designers present the idea of the game. This phase is important since it establishes the context, the content, the use of media, and the pedagogical objectives. In the design phase, designers must specify the mechanics of the game. Then follows the development stage, where programmers must do the work. In the implementation phase, instructors and students enter the game portal to test the game. Finally, the evaluation phase measures whether the game satisfies the specifications described in the analysis phase (See Fig. 1) (Nadolski et al., 2008).

Figure 1: EMERGO Methodology Model

Marfisi-Schottman (2012) presents a methodology composed of seven phases which he calls LEGADEE (Learning Game Design Environment) (see Fig. 2). In this methodology, the first two phases are dedicated to listening to the customer's needs and establishing the specifications and requirements of the game. In the third phase, academics and developers jointly describe the learning scenarios in the game.
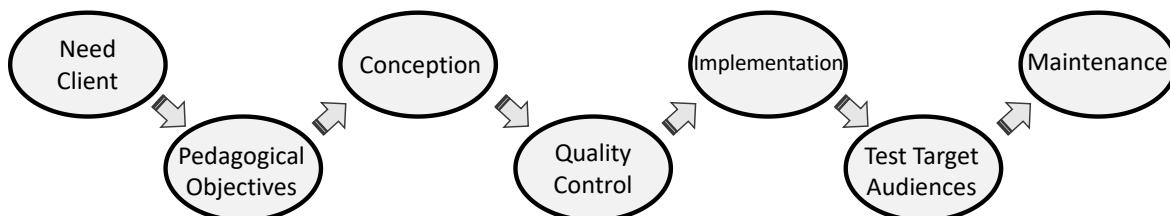

Figure 2: LEGADEE Methodology Model

Barbosa et al. (2014) propose a new methodology for the creation of a serious game. They suggest only three stages: The History of the Game, Main Game, and Learning Mechanisms. For the authors, the design must contain a story that introduces the game. The game contains different scenarios, and in each scenario, players must overcome various challenges. To overcome these challenges, players must put various knowledge into practice (Barbosa et al., 2014). The proposal of this methodology is reduced. The authors suggest incorporating

scenarios and a set of challenges in each scenario (see Fig. 3). The proposal does not include a discussion about the learning contents, the different types of users, the goals of the game, or the way in which learning is measured.
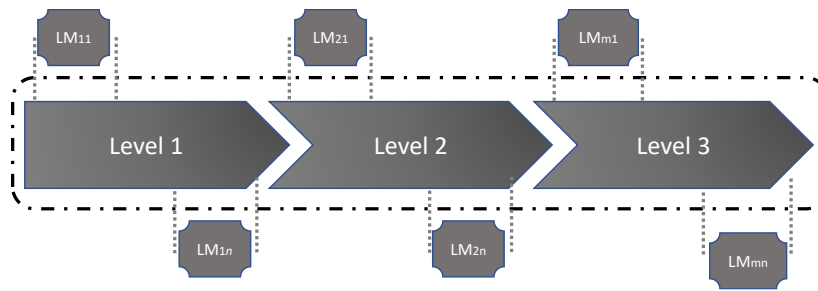

Figure 3: Barbosa Methodology Model

Cano et al. (2016) define a methodology for creating serious games for children with hearing problems. They call this methodology MECONESIS, which includes four phases (see Fig. 4). His research presents a traditional software development methodology, which uses metadata such as Instructional Management System to describe scenarios and BPMN to model processes. The analysis phase contains three very important parts, 1) defining the needs of use, 2) establishing pedagogical and recreational objectives, and 3) establishing the interests and needs of the user. While the pre-production phase is related to the design of the game interface. This part includes design patterns, software patterns for implementation, and design guides for children with hearing impairments (Cano et al., 2016).
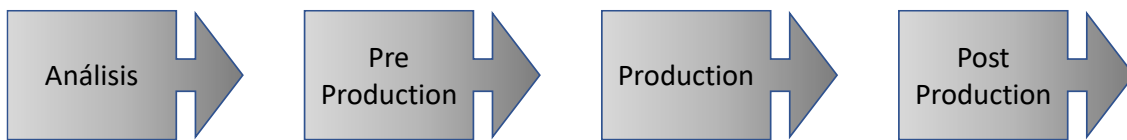

Figure 4: MECONESIS Methodology Model

De Lope (2017) presents a methodology that contains five phases: startup, design, production, test, and postproduction (see Fig 5). The design phase includes suggestions on a set of key elements such as the setting, the characters, and the educational challenge. The game structure considers scenes, actions, and dialogues. However, it is not presented how the learning contents are included in the game.
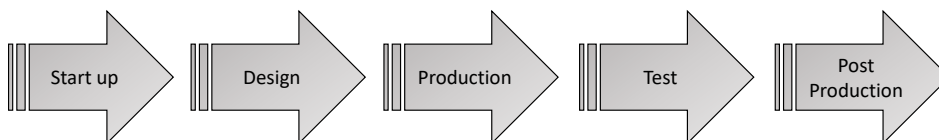

Figure 5: De Lope Methodology Model

Silva (2019) proposes a methodology that emphasizes the development stage of the project before the production of the game. He covers a significant number of steps to define the learning mechanisms in a serious educational game. Fig. 6 shows the diagrams of the steps that the author considers important. Silva explains that the steps represented by a rounded rectangle are related to learning mechanisms or learning outcomes, while the other rectangles are associated with game features. He adds that the dashed lines signify iterative loops, where the mechanics can be refined based on user experience or learning outcomes.
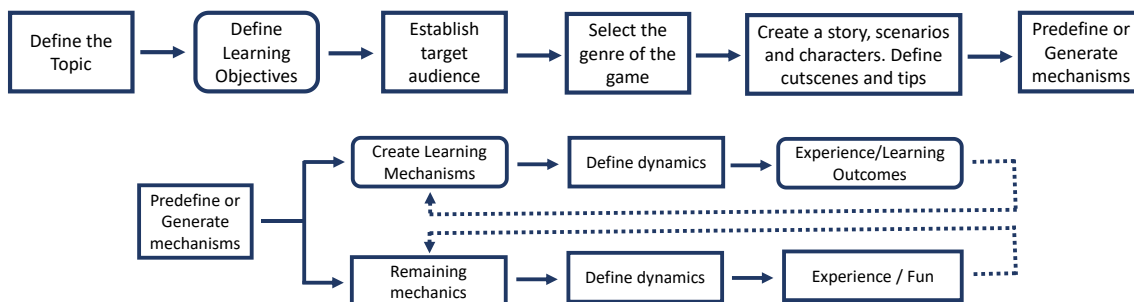

Figure 6: Silva Methodology Model

3.   Proposal for a Participatory Methodology

The literature narrates the benefits of using SGs in the classroom. However, the creation of each serious game is not a simple or easy task, it is frequently that the expectations of the educational designer or the user are not satisfied. There are few methodologies that have been proposed that contemplate an integral design, or that explicitly specify the tasks that must be carried out in each stage. While it is true that the production stage (or development) belongs to the developers, and the testing phase with users regularly belongs to the academic counterpart, the design stage is the opportunity to work collaboratively. The methodology that authors propose has five phases (see Fig. 7), however the purpose of this article is to focus on the first phase (see Fig. 8).

The first phase begins with the creation of a team that integrates experts in software development, experts in pedagogy and experts in games. The authors suggest dividing this phase into different elements: a) Pedagogical elements, b) game definition, and c) interaction design and data generation. These three elements are shown in Fig. 8.
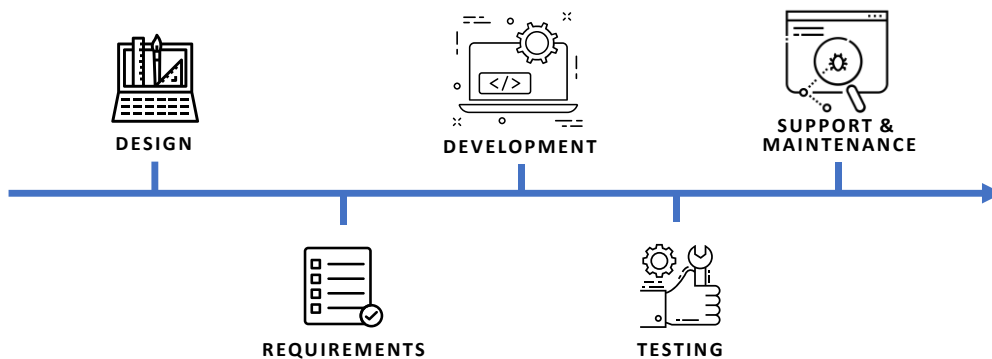

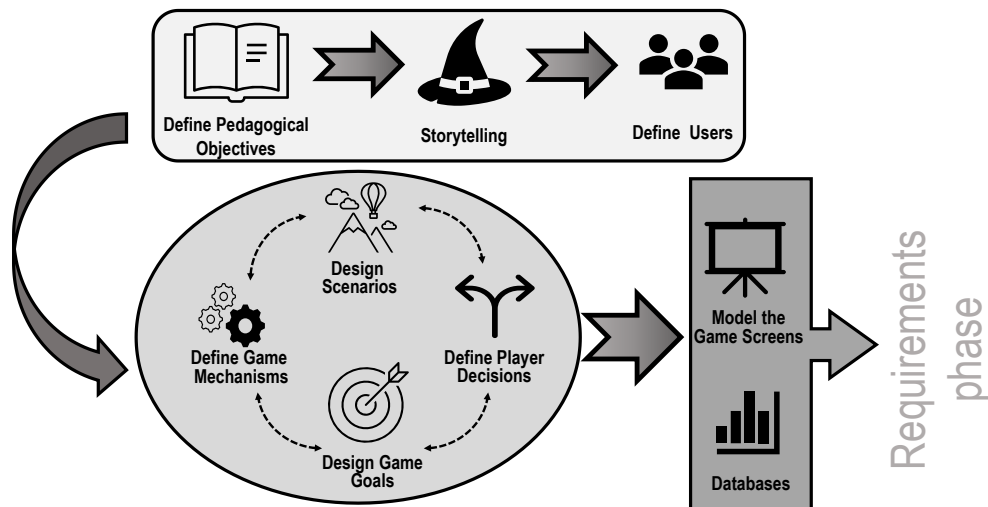**Figure 7: Proposal for a New Participatory Methodology**

Figure 8: Proposal for the Design Phase

3.1   Pedagogical Elements

The birth of the project must come from the academic part, it should come from an idea to transmit knowledge or develop a skill in students and assume that a playful tool can help in it.

Formulation of pedagogical objectives. In this part, we recommend using Bloom's taxonomy to specify the scope that is desired when using the game. It is recommended to start with the most basic verbs in taxonomy. It is also possible that it is declared to develop some kind of competence in the students. In any case, the statement of these objectives should be the guide for the development of the game. On the other hand, this statement is known as product purpose definition. The definition helps the client and developer to have clear objectives that allow comparing the product and defining whether it meets the requirements of the client.

Creation of Storytelling. The development of the story should be a creation of the pedagogical expert along with the game expert. The story must be compelling, generate commitment from the students to find a solution, preferably. The challenges or dare of the game must be aligned with the contents of the topic under study. A congruence is expected between the decisions made by the players and the effects that are observed in the game. If the consequences are aligned or congruent with the real world, students will be able to obtain more learning. Storytelling provides context for the player and introduces relevant topics to the game.

Define Users. The definition of users is important because this must be relevant to the story. If users have little familiarity with the problem, then storytelling should be more scrupulous, explaining every detail more precisely. If, on the contrary, the users have experience in the concepts that the game handles, we must take care that the game has greater depth, and the level of difficulty should be challenging for the users.

3.2 Game Definition

This element is fundamental in this phase and teamwork of the three team members (the academic expert, the game expert, and the developer) is suggested. The definition of each factor depends on the definition of the other components. In this sense, there is an interaction between the four features involved in this step. All the elements are interconnected, and that is why it cannot be seen as a set of serial steps, but rather as an iterative process to bring the right solution from all disciplines and this supposes a continuous adjustment between each one of them.

Define Game Mechanisms. This component is one of the most important. Very often, the definition of the mechanisms also means the way in which the players will create strategies or make decisions. This is why these mechanisms must be clear to all players, each one of them must understand how they can advance in the game and what are the set of available options. The pedagogical expert must make these mechanisms congruent with the learning objectives, the game expert should take care that the mechanisms are fun and challenging, finally, the developer must be present in these discussions since this will be key for technological development. It is desirable that unexpected events occur that challenge the creativity of the player. Performing the same operation throughout the game is not very motivating for the participants.

In this step, it is important to specify if the game is individual or collaborative, asynchronous or synchronous, if the decisions of one player affect the scenarios of other participants, how many rounds should be played, etc. It is recommended to write and fully define the rules of the game.

Design scenarios. A game could represent a continuous story, or it could be divided into different parts, or scenarios, or simply, in turns. Each scenario could represent a continuation of the story, or it could be a different story with different features, facts, situations, or characters. The scenarios offer the opportunity to generate new variables, new decisions, new interactions, new challenges, or to increase the level of difficulty. This is why it is important that the academic expert is the one who develops this part together with the game's expert. Obviously, it is important that the developer is present in this discussion to understand what variables should be incorporated, and how these variables will relate to the existing ones.

Design Game Goals. The academic expert defines the goal of the game, and it is desirable that the rules are clear to all players before they start the game. The objective is to describe how to win or what the player must achieve to be successful. What the players do in the game must be related to the objectives of the game. If the players make a set of decisions, hopefully this will provide a score for the player's performance within the game. It is to be expected that the person who obtains the highest scores demonstrates greater skill or knowledge than other players. This also means that game goals and learning goals must be aligned.

Define Player Decisions. This part is focused on generating engagement and fun, but they must be aligned with the pedagogical objectives. The decisions of the players or those actions that they must carry out are focused on demonstrating the skills or knowledge acquired. Every time the player interacts with the game, it is an opportunity to demonstrate this learning. Within a well-designed game, the decisions could show the level of proficiency that the participant has acquired knowledge or developed a skill.

3.3 Screens and Databases

This is the last part of the design phase. As in most of the design, it is desirable that the three experts work collaboratively and establish agreements before moving on to the requirements phase.

Model the Game Screens. This step is important because all the elements that the players will have access to when they must perform an action must appear on them. It is possible that at that time, players need some type

of data, notification, or relevant information. In this case, it is convenient for the pedagogical expert to point it out so that the other participants can propose the way in which the information or events that should be displayed on the different screens should be established.

Define Databases. This component is important in terms of the feedback that must be provided to the participants to provide them with a better learning experience. The authors suggest that this part should be defined in terms of what are the decisions or actions that show that the participants have acquired knowledge or developed a skill. The intention of an educational game is to provide information to tutors and participants in relation to the achievements. Sometimes it will be necessary to save the player's decisions throughout the game, at other times it will be enough to save the player's final score. It is also convenient to define if the players will have access to the results of other players (so that they can compare their performance).

4. Conclusions

The interest in the development of computer games that can be used as educational tools is evident. This is due to the multiple benefits that games have reported in the literature in recent years, the type of student that is coming to the classroom, and the development of information and communication technologies.

There are some proposals on various methodologies that can be used in the creation of games. However, there is a lack of detail in the steps that should be followed at each stage. There are currently no practical guidelines for what academics, game experts, and developers should work with at the various stages.

In this article we try to detail only the stage that corresponds to the game design, trying to be specific in what should be discussed during this phase. The interest in narrating this element is that, from our experience, many projects fail or last longer than expected because this phase is not worked with the required details. The goal is to raise awareness that in the vast majority of cases, developers, academics, and game experts use a different language, so joint work is essential for the development of common ideas within the group.

Acknowledgements

References

Barbosa, A.F.S. et al. (2014) 'A New Methodology of Design and Development of Serious Games', International Journal of Computer Games Technology, 2014, pp. 1–8. Available at: https://doi.org/10.1155/2014/817167.

Bergeron, B.P. (2008) 'Learning & retention in adaptive serious games', Studies in Health Technology and Informatics, 132, pp. 26–30.

Cano, S. et al. (2016) 'Toward a methodology for serious games design for children with auditory impairments', IEEE Latin America Transactions, 14(5), pp. 2511–2521. Available at: https://doi.org/10.1109/TLA.2016.7530453.

Carrión, M., Santórum, M., Pérez, M., & Aguilar, J. (2017, October). A participatory methodology for the design of serious games in the educational environment. In 2017 Congreso Internacional de Innovacion y Tendencias en Ingenieria (CONIITI) (pp. 1-6). IEEE.

Dörner, R. et al. (eds) (2016) Serious Games. Cham: Springer International Publishing. Available at: https://doi.org/10.1007/978-3-319-40612-1.

Graafland, M., Schraagen, J.M. and Schijven, M.P. (2012) 'Systematic review of serious games for medical education and surgical skills training', British Journal of Surgery, 99(10), pp. 1322–1330. Available at: https://doi.org/10.1002/bjs.8819.

Gros, B. (2016) 'The Dialogue Between Emerging Pedagogies and Emerging Technologies', in B. Gros,

Kinshuk, and M. Maina (eds) The Future of Ubiquitous Learning. Berlin, Heidelberg: Springer Berlin Heidelberg (Lecture Notes in Educational Technology), pp. 3–23. Available at: https://doi.org/10.1007/978-3-662-47724-3_1.

Kiili, K. (2005) 'Digital game-based learning: Towards an experiential gaming model', The Internet and Higher Education, 8(1), pp. 13–24. Available at: https://doi.org/10.1016/j.iheduc.2004.12.001.

Lugrin, J.-L. et al. (2013) 'Immersive FPS games: user experience and performance', in Proceedings of the 2013 ACM international workshop on Immersive media experiences. MM '13: ACM Multimedia Conference, Barcelona Spain: ACM, pp. 7–12. Available at: https://doi.org/10.1145/2512142.2512146.

Madani, K., Pierce, T.W. and Mirchi, A. (2017) 'Serious games on environmental management', Sustainable Cities and Society, 29, pp. 1–11. Available at: https://doi.org/10.1016/j.scs.2016.11.007.

Marfisi-Schottman, I. (2012). Méthodologie, modèles et outils pour la conception de Learning Games (Doctoral dissertation, Lyon, INSA).

Meij, H., Veldkamp, S. and Leemkuil, H. (2020) 'Effects of scripting on dialogues, motivation and learning outcomes in serious games', British Journal of Educational Technology, 51(2), pp. 459–472. Available at: https://doi.org/10.1111/bjet.12851.

Monaco, M. and Martin, M. (2007) 'The Millennial Student: A New Generation of Learners', Athletic Training Education Journal, 2(2), pp. 42–46. Available at: https://doi.org/10.4085/1947-380X-2.2.42.

Nadolski, R.J. et al. (2008) 'EMERGO: A methodology and toolkit for developing serious games in higher education', Simulation & Gaming, 39(3), pp. 338–352. Available at: https://doi.org/10.1177/1046878108319278.

Naul, E. and Liu, M. (2020) 'Why Story Matters: A Review of Narrative in Serious Games', Journal of Educational Computing Research, 58(3), pp. 687–707. Available at: https://doi.org/10.1177/0735633119859904.

Pacheco-Velazquez, E. (2022) 'Effects of the use of simulators and an online platform in logistics education', International Journal on Interactive Design and Manufacturing (IJIDeM), 16(2), pp. 439–457. Available at: https://doi.org/10.1007/s12008-021-00791-z.

Pacheco-Velazquez, E.A. and Aguilar-Avalo, M. (2019) 'GOAL: Generating Learning Opportunities in Logistics', in 2019 IEEE Global Engineering Education Conference (EDUCON). 2019 IEEE Global Engineering Education Conference (EDUCON), Dubai, United Arab Emirates: IEEE, pp. 761–769. Available at: https://doi.org/10.1109/EDUCON.2019.8725075.

Ravyse, W.S. et al. (2017) 'Success factors for serious games to enhance learning: a systematic review', Virtual Reality, 21(1), pp. 31–58. Available at: https://doi.org/10.1007/s10055-016-0298-4.

Riedel, J. C., & Hauge, J. B. (2011, June). State of the art of serious games for business and industry. In 2011 17th International conference on concurrent enterprising (pp. 1-8). IEEE.

Samčović, A. (2018) 'Serious games in military applications', Vojnotehnicki glasnik, 66(3), pp. 597–613. Available at: https://doi.org/10.5937/vojtehg66-16367.

Tan, A.J.Q., Lau, C.C.S. and Liaw, S.Y. (2017) 'Paper title: Serious games in nursing education: An integrative review', in 2017 9th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games). 2017 9th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games), Athens, Greece: IEEE, pp. 187–188. Available at: https://doi.org/10.1109/VS-GAMES.2017.8056599.

Tilvawala, K., Sundaram, D., & Myers, M. (2019, August). Serious games for sustainable development: A decision-driven transformative approach. In Americas Conference on Information Systems.