An initial Framework for Adaptive Serious Games based on a systematic literature review

Alvaro Marcos Antonio de Araujo Pistono [1][0000-0001-6863-0453], Arnaldo Manuel Pinto Santos[2][0000-0001-5139-6728] and Ricardo José Vieira Baptista[2][0000-0002-0317-6381]

[1] Universidade de Trás-os-Montes e Alto Douro, Quinta de Prados 5000-801, Portugal
[2] Universidade Aberta, Lisboa 1269-001, Portugal

Abstract. Serious Games have been used in professional training to increase employee engagement and improve the results of training initiatives. This work intends to investigate the influence of game elements, in adaptable Serious Games, according to the users' interactions, on the increase of engagement in the game itself and, as the main goal, on the learning results and the transfer of the acquired knowledge and practised skills to the daily work activities. Using the Design Science Research - DSR methodology, this study aims to develop a framework for the development and evaluation of Serious Games to improve the user experience, the learning outcomes, the transfer of knowledge to work situations, and the application of the skills practised in the game in real professional scenarios. This paper presents an initial Framework for Adaptive Serious Games derived from a systematic literature review. The next steps in this investigation are pointed out following the DSR methodology.

Keywords: Framework, Adaptive, Serious Games, Professional Training, Learning Outcomes.

1 Introduction

In professional training, Serious Games have been used in various contexts for more than two decades in various training courses, such as courses on compliance or related to specific procedures.

Among the different aspects considered relevant for the development of efficient Serious Games, fun, an inherent characteristic of games, is one of the most important, as cited by Ferreira de Almeida & dos Santos Machado (2021). Thus, to avoid Serious Games from becoming boring or stopping being fun is fundamental to maintaining the game characteristic.

Martin, Casey, & Kane (2021) argue that dynamic game adjustment, to prevent tasks from being too easy or difficult, and thus maintain the player's focus on an in-game learning task, is important to provide both a challenging and fun experience and effective learning.

As Lopes & Bidarra (2011) pointed out, the lack of adaptability of games can result in two consequences. The first is the loss of efficiency in learning if users perceive the game's dynamics and evolve without achieving the learning objectives. And, also, the

impossibility of repeating the application of the game for the same users, once they already know its content.

Among the biggest challenges for the efficient application of Serious Games are adaptating and evaluating the results. In this sense, Mayer (2014) highlights that more empirical research is needed on the contribution of Serious Games to learning.

1.1 **Framing**

This research aims to propose a decision framework concerning the adaptation of Serious Game elements in the professional training context.

It is intended that this framework will improve:

- The player's experience and involvement in the game;
- The learning outcomes;
- The transfer of knowledge to work situations;
- Application of skills practised in the game in real-life scenarios during professional activities.

The following research questions were identified to achieve the proposed goal:

1. What is the influence of the game elements?
2. How should the game elements be adapted?
3. How to classify and organize the game elements to adapt and meet the previously established objectives?

In this way, it is intended to relate the game elements to player involvement, learning, and the transfer of knowledge gained and activities practised in the game to real work scenarios.

2 Methodology

Design Science Research - DSR proved to be more appropriate for this research because, as pointed out by Dresch, Lacerda, & José Antonio Valle Antunes Júnior (2020), this methodology has the characteristic of investigating how things should be, while the other methodologies, such as case study or action research, are used to investigate how things are or behave.

This methodology is also suitable for the research in progress, as it has the design and development of an artefact (framework) as its main part.

To conduct this investigation, considering the questions formulated in the framing section of this paper, the process sequence of the model presented by Peffers, Tuunanen, Rothenberger, & Chatterjee (2007) for DSR was adopted.

Concerning this model, this research started at the first entry point, identifying the problem: Verification of the efficiency of using Serious Games, as a learning initiative, in professional training, restricted to e-learning.

Following this methodology, initial exploratory research was conducted in the first stage, problem identification and motivation. Then a Systematic Literature Review was performed, according to the protocol provided by Kitchenham (2004), on adap-tive Serious Games applied to professional training.

In this literature review, 3 cycles of searches were performed, which, after applying the inclusion, exclusion, and classification criteria, resulted in 53 final publications.

Among the publications analyzed, there were 7 literature reviews, in distinct areas, complementary and relevant to the review in question: Effectiveness of instructional games (Hays, 2005); Practices used in Serious Games research (Wouters, van der Spek, & van Oostendorp, 2009); Engagement in games for entertainment (Boyle, Connolly, Hainey, & Boyle, 2012); Empirical studies on gamification (Hamari, Koivisto, & Sarsa, 2014); Evaluation of Serious Games (Calderón & Ruiz, 2015); Empirical evidence of the impacts and outcomes of computer games and Serious Games (Boyle et al., 2016); Serious games and gamification in professional training (Larson, 2020).

After the Systematic Literature Review, it was possible, in the next stage, definition of the objectives of the solution, confirm the originally proposed objective of the investigation and define the purposes of the framework.

Continuing the investigation, in the design and development stage, an initial proposal for the framework was developed.

Following the investigation, in this stage, data were collected in focus groups and interviews with experts, so that the triangulation of data collection methods (Coutinho, 2014) could be done next, and thus perform the first evaluation of the framework, formative and artificial, according to the FEDS framework (Venable, Pries-Heje, & Baskerville, 2016).

3 Proposed framework

3.1 Purposes

The purposes determined for the framework were:

- Include learning outcomes as dimensions of the framework;
- Group the dimensions into learning and game;
- Consider the forms of adaptation in these two groups of dimensions;
- Be used for both development and evaluation of adaptive Serious Games;
- Be used to improve Serious Games by comparing framework ‘s application at the development stage (development team) and the evaluation stage (players).

3.2 Framework for Adaptive Serious Games (FA-SG)

From the systematic literature review and the analysis of the existing frameworks for Serious Games, a framework was developed, considering all the aspects found in this research, so that it would be possible to approximate the learning and engagement results in the game to the expected results, using the adaptation of the Serious Game.

Each dimension can be discretized into relevant aspects and each aspect into items to be analyzed according to the suitability of their application in the Serious Game.

Thus, the analysis can be performed at three levels of detail, from the most specific to the most general:

- Component items of each relevant aspect of the dimension;
- Relevant aspects of the dimension, if there are limitations to answering all the items of an aspect;
- Dimension as a whole.

According to the resources available (knowledge or time, for example), it is possible to mix the depth of analysis for each dimension.

3.3 Learning dimensions

Concerning learning dimensions, each dimension, aspect and item are described in table 1.

Table 1. Learning dimensions of the Framework for Adaptive Serious Games (FA-SG).

Content / context / framing	
Aspect	**Items**
Content clarity	Are the terms and expressions used clear and familiar (or have they been defined previously)? Is the flow of the text direct and unambiguous? When necessary, because the language is very specific, is there a glossary of terms?
Adequate context	Are the situations presented or exemplified possible situations in the reality of the student's work? Are the most common situations addressed as most relevant? Are exceptional situations presented as such?
Content level	Are the necessary explanations given for the student to absorb the content at each stage of the Serious Game? Throughout the content, the student can relate previous content to new content that is being presented?
Content coverage	Does the content reflect all the knowledge and/or skills that the student will need in his/her daily work? Does the content cover topics that are not related to the student's work only to relate them to the content, to provide external connections, highlighting them as non-essential?
Instructional elements	
Aspect	**Items**
Learning objectives approach	Are all instructional objectives addressed? Are there clear instructions for how students are to demonstrate achievement of each objective? Are the objectives ordered in increasing complexity concerning the knowledge and skills?
Evaluation types	Do the evaluations cover all the learning objectives of the Serious Game? Do the evaluations clearly indicate the learning outcomes?
Cognitive load and memory usage	Are there situations that present players' previous experiences, which allow these to be related to the game situations?
Learning outcomes	
Aspect	**Items**
Objectives' compliance	Are all the enabling objectives for a learning objective clearly depicted and in a sequence that facilitates their achievement? Do the learning objectives have a clear relationship to the expected learning outcomes? Is there a relationship between the objectives

	and the results and goals of everyday work? Is the assessment of the results appropriate to the expected results, according to their level (Reaction, Learning, Behavior, Results)?
Challenges' alignment	Are the situations presented to the players related to the expected results? Is it possible to transfer a situation from the game to the work routine and associate learning with everyday tasks?
Level progression	Does the game provide for incremental learning outcomes? Can learning outcomes be built on previous experiences in the game? Does the game enable the relationship between the learning outcomes, favouring a holistic view of the topics covered?
Opportunities to redo tasks	Is it possible to redo tasks? How are the tasks redone, i.e., in the same way, with some kind of help/feedback? Are all attempts to execute a task displayed to the player?
Learning adaptation	
Aspect	**Items**
Learning curve	Is the pace of the game changed when a player makes a mistake? Does the number of tasks change according to the learning results? Is the type of task changed according to the learning outcomes? Is the content adapted according to the learning results?
Feedbacks	Are the game feedbacks fixed? Are the feedbacks adapted based on the player's characteristics? Are the feedbacks adapted according to the player's evolution in the game? Are the feedbacks adapted to motivate the player's evolution?
Evolution / goals	Are the game situations changed according to the player's evolution? Is the sequence of presentation of the situations/challenges variable according to the results obtained throughout the game?
Content change	Does the content adapt to provide better learning outcomes? Are learning outcomes used to adapt the game content?

3.4 Game dimensions

Table 2 shows the dimensions, aspects and corresponding items related to game dimensions of the Framework for Adaptive Serious Games.

Table 2. Game dimensions of the Framework for Adaptive Serious Games (FA-SG).

Game mechanics	
Aspect	**Items**
Interaction types	Are the forms of interaction appropriate for the players? Are the forms of interaction explained initially to the players? Do the players receive the necessary instructions and have opportunities to practice before the game?
Game elements	Do the game components characterize the artefact as a game? Are the game components harmonious with each other? Do the game elements portray the context?

Reward structures	Are there reward structures in the game? Are the reward structures clear to the players? Are the reward structures appropriate for the players' evolutions?
Tasks	Are the tasks that the player must perform associated with the learning objectives? Are the tasks adapted according to the outcomes of the game? Do the tasks cover all learning objectives?
Game environment	
Aspect	**Items**
Aesthetics	Is the aesthetic appropriate to the theme? Is the aesthetic appropriate to the application context? Is the aesthetic appropriate for the target audience?
Audio	Do the sound effects correctly reflect the game states? Do the sound effects complement the environment, adding useful sensory information? Do the sound effects not distract the player at times when they should be focusing on some information?
Immersion	Do the game elements and mechanics provide the degree of immersion necessary to engage the player during key moments in the game? Do the forms of interaction help the player's immersion in the game context?
Narrative	Does the narrative aggregate the other elements of the game? Is the narrative appropriate to the game's context? Is the narrative appropriate to the target audience?
Challenges	At each level, are the challenges appropriate to the knowledge and skills of the players? Do the challenges highlight the learning objectives? Do the challenges present environments that motivate the player to solve them?
Results	
Aspect	**Items**
Points	Are points recorded and displayed for the players? Are the scoring criteria variable, according to the player's performance and level, for example? Do the points influence the performance or evolution of the player, for example by assigning bonuses or burdens?
Choices	Can players make choices during the game? Are the choices variable, according to the player's level or score, for example? Are the available choices adapted to maintain the player's flow state, at each moment of the game? Are the available choices optimized to bring the learning outcomes closer to the expected values?
Levels	Is the game organized in levels according to the learning objectives? Are the levels adaptable according to player performance? Can the sequence of levels be changed according to the player's performance?
Rewards	Are there rewards for players' actions? Are the rewards tailored, according to the student's history of actions, for example?
Game adaptation	
Aspect	**Items**

Adaptation decisions	Is it possible to adjust the difficulty of the game? Does the game provide for interpretation and adaptation from player interactions, such as an intelligent tutoring system?
Game elements change	Do the game elements adapt from information such as the player's activity history? Do the game elements adapt according to the player's progress in the game?

4 Conclusions and future work

The proposed framework for adaptive Serious Games was designed to approximate the game's learning and engagement results to the expected results, using the adaptation of the Serious Game.

The next steps, following the DSR, are:

- Data analysis and triangulation, from the systematic literature review, the focus groups, and the expert interviews, to identify confirmations, divergences, and complements, serving as an evaluation of the proposed framework, still in the design and development stage;
- Application of the initial framework to existing Serious Games - Framework for evaluation;
- Applying the framework to a prototype:
  - Conceptual - Framework for development;
  - Practical - Framework for evaluation and development;
- Evaluation of the framework; and
- Iteration for the improvement of the framework, i.e. changing the framework based on the results of its evaluation, refining the sets of dimensions, and investigating the relationship between them and their application options.

References

1. Boyle, E. A., Connolly, T. M., Hainey, T., & Boyle, J. M. (2012). Engagement in digital entertainment games: A systematic review. Computers in Human Behavior, 28(3), 771–780. https://www.sciencedirect.com/science/article/pii/S0747563211002640
2. Boyle, E. A., Hainey, T., Connolly, T. M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C., & Pereira, J. (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, 178–192. https://doi.org/10.1016/j.compedu.2015.11.003
3. Calderón, A., & Ruiz, M. (2015). A systematic literature review on Serious Games evaluation: An application to software project management. Computers & Education, 87, 396–422. https://doi.org/10.1016/j.compedu.2015.07.011
4. Coutinho, C. P. (2014). Metodologia de investigação em ciências sociais e humanas. https://vpn.uab.pt/https/www.google.com/books?hl=pt-BR&lr=&id=uFmaAwAAQBAJ&oi=fnd&pg=PT3&dq=%22Metodologia+de+investiga%C3%A7%C3%A3o+em+Ci%C3%AAncias+Sociais+e+Humanas%22&ots=GheF0Bi_S5&sig=yUNphzd4I5_AgeVxTFgW33Bt7V0

5. Dresch, A., Lacerda, D. P., & José Antonio Valle Antunes Júnior (Junico Antunes). (2020). Design Science Research: Método de Pesquisa para Avanço da Ciência e Tecnologia. Bookman Editora. https://play.google.com/store/books/details?id=M63XDwAAQBAJ
6. Ferreira de Almeida, J. L., & dos Santos Machado, L. (2021). Design requirements for educational serious games with focus on player enjoyment. Entertainment Computing, 38. https://doi.org/10.1016/j.entcom.2021.100413
7. Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does Gamification Work? -- A Literature Review of Empirical Studies on Gamification. 2014 47th Hawaii International Conference on System Sciences, 3025–3034. https://doi.org/10.1109/HICSS.2014.377
8. Hays, R. T. (2005). The effectiveness of instructional games: A literature review and discussion. https://apps.dtic.mil/sti/citations/ADA441935
9. Kitchenham, B. (2004). Procedures for performing systematic reviews. Keele, UK, Keele University, 33(2004), 1–26. https://www.elizabete.com.br/rs/Tutorial_IHC_2012_files/Conceitos_RevisaoSistematica_kitchenham_2004.pdf
10. Larson, K. (2020). Serious Games and Gamification in the Corporate Training Environment: a Literature Review. TechTrends, 64(2), 319–328. https://doi.org/10.1007/s11528-019-00446-7
11. Lopes, R., & Bidarra, R. (2011). Adaptivity Challenges in Games and Simulations: A Survey. IEEE Transactions on Computational Intelligence in AI and Games, 3(2), 85–99. https://doi.org/10.1109/TCIAIG.2011.2152841
12. Martin, S.M., Casey, J.R and Kane, S. (2021). Serious Games in Personalized Learning – New Models for Design and Performance. New York: Routledge.
13. Mayer, R. E. (2014). Computer games for learning: An evidence-based approach. MIT Press. https://www.google.com/books?hl=pt-BR&lr=&id=VckIBAAAQBAJ&oi=fnd&pg=PR7&dq=Mayer+2014+game+review&ots=5xIU86Tf9F&sig=5dQmaQfr4NlEcBWIl8YNHmJgnHc
14. Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. Journal of Management Information Systems, 24(3), 45–77. https://doi.org/10.2753/MIS0742-1222240302
15. Venable, J., Pries-Heje, J., & Baskerville, R. (2016). FEDS: a Framework for Evaluation in Design Science Research. European Journal of Information Systems, 25(1), 77–89. https://doi.org/10.1057/ejis.2014.36
16. Wouters, P., van der Spek, E. D., & van Oostendorp, H. (2009). Current Practices in Serious Game Research: A Review from a Learning Outcomes Perspective. In Games-Based Learning Advancements for Multi-Sensory Human-Computer Interfaces: Techniques and Effective Practices (pp. 232–250). IGI Global. https://doi.org/10.4018/978-1-60566-360-9.ch014