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Influence of adaptability of Serious Games on learning outcomes and the application of knowledge and skills in professional training

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Influence of adaptability of Serious Games on learning outcomes and the application of knowledge and skills in professional training

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Abstract

Serious Games have been used in professional training to increase employee engagement and improve the results of training initiatives in this context. This work intends to investigate the influence of game elements, in adaptable Serious Games, according to the users' interactions, in the increase of engagement in the game itself and, as the main objective, in the learning outcomes and the transfer of the acquired knowledge and practised skills to activities in the daily work. Using the Design Science Research methodology, this study is intended 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 skills practised in the game in real professional scenarios.

Keywords: Serious Games; adaptation; professional training; learning outcomes; framework

1. INTRODUCTION

Serious Games are used in various areas and with different contents to involve their users in serious activities.

Their contributions to improve learning outcomes, such as acquiring knowledge or skills, are evidenced in some research, both in the academic and corporate markets.

Many are studies about Serious Games, in several areas. One of the areas in which they are widely used is science education, as described in the systematic literature review conducted by Kara (2021), which points out that these games have been used since elementary school.

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

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

Martin, Casey, & Kane (2021) argue that dynamic game adjustment, to avoid tasks being too easy or difficult, to keep the player's focus on a learning task within a game, is important to provide both a challenging and fun experience and effective learning.

As Lopes & Bidarra (2011) highlighted, the lack of adaptability of games can result in two consequences. Firstly, in the loss of efficiency in learning, when users perceive the game dynamics

and evolve without achieving the learning objectives. Lately, in the impossibility of applying the game again for the same users, as they already know its content.

It is noteworthy that adaptation and evaluating of their results are among the existing biggest challenges for the efficient application of Serious Games.

Also, few existing evidence-based approaches are used to assess the contribution of Serious Games to learning, as highlighted by Mayer (2014).

1.1. Contribution

This article presents a research in progress on Serious Games in the context of professional training, which seeks to relate learning outcomes to game elements and their adaptation.

This research's main objective is to design and propose a decision framework concerning the adaptation of the elements of Serious Games to improve:

- Player's experience and engagement in the game;

- Learning outcomes;

- Knowledge transfer to work situations;

- Application of the skills practised in the game in real scenarios during professional activities.

To achieve the proposed objective, the following research questions were identified:

- RQ1: What is the influence of the game elements?

- RQ2: How should the game elements be adapted?

- RQ3: How to classify and organize the game elements to adapt and meet previously established goals?

Thus, it is intended to relate the game elements to the players' engagement, learning and transfer of the acquired knowledge and practised activities in the game to real work scenarios.

This paper presents the research in progress for developing a framework for Serious Games, according to the processes' sequence of the model presented by Peffers, Tuunanen, Rothenberger, & Chatterjee (2007) for Design Science Research - DSR.

1.2. Motivation

Initially, a systematic literature review was conducted that identified the challenges related to the application of Serious Games and their relationship with learning outcomes and the existence of adaptable Serious Games in a general context.

It was also possible to identify the absence of research in the context of adaptive Serious Games in professional training that relate this adaptive feature to the learning outcomes.

Therefore, the primary motivation for this research is related to the improvement of the teaching-learning process in professional training, using adaptive Serious Games that can relate their characteristics, or game elements, to the learning outcomes.

2. RELATED WORK

Although sometimes playing and learning seem contradictory activities, as cited by Huynh-Kim-Bang, Wisdom, & Labat (2010), these two activities can be brought together in Serious Games, exploiting each (game and instruction) characteristics to obtain the best results, taking advantage, for example, of the engagement potential of games to increase students' hours of dedication to study subjects and associating the challenges of games with those of problem-solving learning.

Another notable feature of games is the engagement of their players, described by Boyle, Connolly, Hainey, & Boyle (2012) as a subjective experience that happens during a game, associated with fun, immersion, "flow", and presence.

Whitton & Moseley (2014) analysed the different definitions and models of engagement about education and games and proposed a model of engagement used in both situations, called by the authors the "engagement with learning" model. This model combines the different types of engagement into two groups, superficial engagement, associated with behaviours and extrinsic motivation, and deep engagement, relating to more significant psychological interaction during an experience. It should be noted that two types of deep engagement are related to games: Passion and incorporation.

Other facts cited by O'Brien & Toms (2008) are the similarities between the learning process and the act of playing. Both are usually long, complex, and difficult; besides, the games are associated with learning because the player needs to learn how to play. The same authors complement this finding with the observation that, just like games, learning is an interactive process that challenges learners and has rules for new knowledge and skills acquisition. Table 1 summarises what is described in Kapp (2012) regarding the influences of game elements.

GAME ELEMENT	INFLUENCE
Abstractions of concepts and reality	- Minimise complexity - Facilitate identification of the cause and effect's relationship - Isolate extraneous factors, providing increased focus - Reduce the time needed to understand concepts
Goals	Add purpose, focus, and measurable results.

Rules	Limit the players' actions.
Conflict, competition and cooperation	Creates an interesting environment by combining limits to progress (conflict), overcoming opponents (competition), and teamwork to achieve collective results (cooperation).
Time	Stimulates players' actions and forces them to act under pressure.
Reward structures (badges, points, rewards, and leaderboards)	Encourage participation. Leaderboards, for example, have been motivating factors for games to be played again and again.
Feedback	Reminds the player of the correct behaviours, thoughts, and actions.
Levels	- Help the narrative progress - Build and reinforce skills - Motivate players to advance to the next levels
Storytelling	- Adds meaning - Contextualizes - Guides actions
Curve of interest	Holds the players' interest from the beginning to the end of the game.
Aesthetics	Creates an immersive environment, improving the gaming experience.
Replay or do-over	It allows players to fail, encouraging exploration, curiosity, and discovery-based learning.

Table 1 – Influence of game elements according to Kapp (2012)

Professional training is one of the applications of Serious Games for, at least two decades, in several contexts: Military (Hays, 2005; Greitzer, Kuchar, & Huston, 2007; Engberg-Pedersen, 2017); Telecommunications (Almeida et al, 2011); General businesses (Donovan & Lead, 2012; Kapp, 2013; Uskov & Sekar, 2014; Boller & Kapp, 2017); Healthcare (Wattanasoontorn, Hernández, & Sbert, 2014); Manufacturing companies (Riedel, Feng, Hauge, Hansen, & Tasuya, 2015); Hospitality (Pabon, 2016); Finance (Larson, 2020).

They have been used in professional training by many companies belonging to different verticals in initiatives related to knowledge acquisition, skills practice, and attitude change.

Although Serious Games are used in several areas of the corporate market, both in training and in other activities, such as in recruitment and marketing/sales (Donovan & Lead, 2012), the measurement of their actual effects on learning is considered by Sousa et al. (2016) one of the biggest challenges for the acceptance of Serious Games in education.

The process of Serious Games assessment may consider several approaches, such as the four levels of evaluation of Kirkpatrick & Kirkpatrick's (2006) and, as advocated by Emmerich & Bockholt (2016), the six components of the Mitgutsch & Alvarado (2012) framework for serious game evaluation.

The Serious Game's assessment can be performed in several ways, through questionnaires, interviews, access/activity records (logs), discussions, videos, frameworks, observations, among other methods listed by Calderón & Ruiz (2015). These same authors found that questionnaires are the most used type of assessment of Serious Games, as shown in Figure 1.
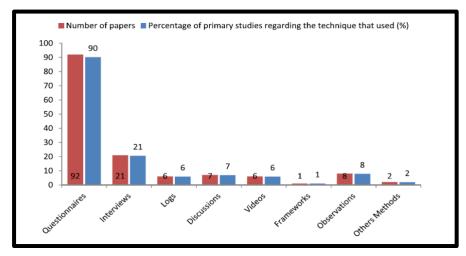

Figure 1 – Types of assessment used in Serious Games, according to Calderón & Ruiz (2015)

Although there is research on Serious Games, Mayer (2014) highlighted that there are still few existing evidence-based approaches to assess the contribution of Serious Games to learning.

In the systematic literature review on the empirical evidence of the impacts and outcomes of using digital games and games for learning conducted by Boyle et al. (2016), research on Serious Games was grouped by type, as shown in Figure 2, into correlational, qualitative, quasi-experimental, RCT and survey.
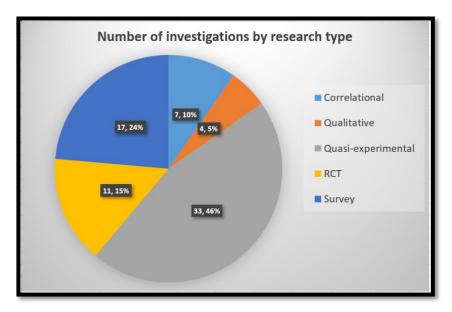

Figure 2 – Number of investigations on games for learning by research type

In this review, Boyle et al. (2016) also identified that the most investigated learning outcome was knowledge acquisition, as shown in Figure 3.
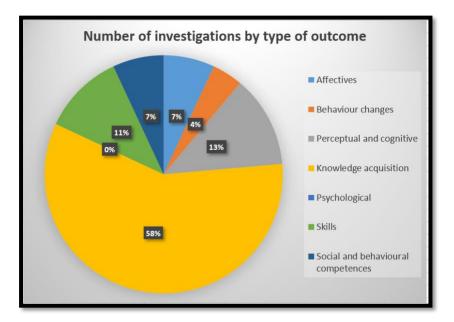

Figure 3 – Number of investigations on games for learning by investigated outcomes

Related to the adaptivity challenges in Serious Games, Lopes & Bidarra (2011) argue that all game components are potentially adaptable through dynamic adjustments, i.e., game objects and worlds, game mechanics, NPCs - Non-Player Characters, narratives, and scenarios or missions.

The frameworks of Serious Games found in the literature review are listed in Table 2, with their main characteristics.

MAIN CHARACTERISTICS OF THE FRAMEWORKS	REFERENCES
● 4DF – Four-Dimensional Framework ● Framework for development of Serious Games ● Four main aspects: Context; learner specification; representation; and pedagogical model or approach	de Freitas & Jarvis (2006)
● Framework for evaluating serious game design ● Basis for studying the relationship between design elements and serious game objectives	Mitgutsch & Alvarado (2012)
● Framework for interactive and iterative scenario generation for Serious Games	Luo, Yin, Cai, Lees, & Zhou (2013)
● Framework focusing on the influence of player cognitive load on learning outcomes ● Three perspectives: Environments; characters; and activities	Huang & Tettegah (2014)

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● Flow Framework ● Dimensions: Antecedents of flow; flow state characteristics; significant factors affecting the design of the learning experience and game-based learning artefacts; and mind lenses	Kiili, Lainema, de Freitas, & Arnab (2014)
● Framework for evaluation-driven serious game design ● The design and evaluation phases are interlinked and should be repeated until the end of the serious game design	Emmerich & Bockholt (2016)
● Framework for iterative evaluation of Serious Games. ● Theoretical, technical, empirical and external bases.	Wilson et al. (2016)
● Framework for Serious Games, with a focus on cultural heritage, that iteratively increments not only functionality but also content ● Four phases: Preliminary; conceptual; development; and evaluation	Andreoli et al. (2017)
● COTS serious game evaluation framework ● Four main dimensions and peripheral dimensions related to game mechanics	Ulrich & Helms (2017)
● LEAGUE – Learning, Environment, Affective cognitive reactions, Game factors, Usability and UsEr ● Conceptual framework for evaluating Serious Games concerning to their scope, definition, and use.	Tahir & Wang (2018)
● SCDGBL – Student Centered Digital Game Based Learning ● Conceptual framework for game-based learning with the learner as the central element	Coleman & Money (2020)

Table 2 – Main characteristics of Serious Games frameworks

3. RESEARCH METHODOLOGY

Some methodologies could be used to address the theme proposed for this research, such as case study, action research, or Design Science Research - DSR. However, the DSR proved to be more appropriate 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 two methodologies are used to investigate how things are or behave.

Moreover, this research considers the design and development of a framework (artefact) as a fundamental part of the research, reinforcing the DSR research methodology choice.

To conduct this research study and considering the questions formulated in the introduction section of this article, the sequence of processes of the model presented by Peffers, Tuunanen, Rothenberger, & Chatterjee (2007) for DSR was adopted, as illustrated in Figure 4.

This investigation has begun in the first entry point, identifying the problem: Verification of the efficiency of using Serious Games in learning in professional training, restricted to e-learning.
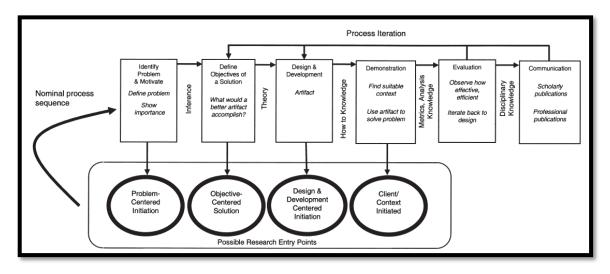
Figure 4 – Process model for the Design Science Research methodology

The first performed activity in this research was a systematic review of the literature on adaptive Serious Games applied to professional training, according to the protocol predicted by Kitchenham (2004), using the same research questions of the ongoing research as review questions. This systematic literature review, conducted in three search cycles, was limited to publications in English and Portuguese and, in the first two search cycles, to review-type publications or those with 20 or more citations, until December 2020.

A refinement of the frameworks' dimensions found in the systematic literature review is being done, as the next step in this research, to define the developing framework dimensions and better attend to its purposes.

4. PROPOSED SOLUTION

After the systematic literature review, the conclusions related to the three proposed review questions are:

- RQ1: Although there are publications regarding the influence of game elements, as cited by Kapp (2012), research is still needed to determine empirical evidence on these influences, especially regarding the added value of some game elements (Mayer, 2014). It was also noted that a significant influence that games can provide is deep engagement;

- RQ2: Potentially, all game elements could be adaptable, which could ensure greater player engagement and greater possibilities for the application of Serious Games. Adaptation of Serious Games can be achieved by parameterisation by the player to different dynamics during the game and is usually based on psychological models. It can be highlighted that Van Oostendorp, Van der Spek, & Linssen (2014) reported that their Serious Game adaptive

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had much higher efficiency regarding learning outcomes when compared to the non-adaptive game;

- RQ3: This research has identified models and frameworks for development and evaluation of Serious Games that can classify and organize the elements of a Serious Game. Although they present different parameters and dimensions, they all consider the existence of the domains of learning and games; and seek to relate the mechanics and elements of games to theories of instruction and learning. However, concerning adaptation, only Luo, Yin, Cai, Lees, & Zhou's (2013) Framework predicts adaptation of the Serious Game, based on scenario generation, depending on player performance and the game missions' objectives.

Analyzing these results and wondering how to approach the identified problem in a straight form, there were proposed the following purposes for the framework:

- To include learning outcomes as framework dimensions;
- To group those dimensions in two sets: Learning and game;
- To consider forms of adaptation in those two groups of dimensions;
- To be able to support both development and evaluation of adaptable serious games;
- To improve serious games by comparing the framework's application in the design/ development stage (development team) and evaluation (Serious Game target).

5. FUTURE WORK

As next steps of this research work, in each phase of DSR, it is intended to:

- Design and development:
  - o Refine the sets of dimensions from the initial framework, investigating the relationship between them and their application options;
- Demonstration:
  - o Apply the framework to evaluate an existing Serious Game;
  - o Apply the framework to a prototype in the development and evaluation of a Serious Game;
- Evaluation:
  - o Use the FEDS framework (Venable, Pries-Heje, & Baskerville, 2016) for DSR artefact evaluation throughout initial development and improvement iterations.

o   Iteratively adjust the framework, returning to the design and development phase if necessary;

- Communication:

    o   Write papers to divulge the advances of this research;

    o   Write a PhD Thesis to document this research.

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