



## Full length article

## Benefits of educational games as an introductory activity in industrial engineering education



Lynceo Falavigna Braghirolli <sup>a,\*</sup>, José Luis Duarte Ribeiro <sup>a</sup>, Andreas Dittmar Weise <sup>b</sup>, Morgana Pizzolato <sup>b</sup>

<sup>a</sup> Graduate Program in Industrial Engineering (PPGEP), Federal University of Rio Grande do Sul (UFRGS), Av. Osvaldo Aranha, 99, 5º Andar, Porto Alegre, RS 90035-190, Brazil

<sup>b</sup> Department of Industrial and Systems Engineering, Federal University of Santa Maria (UFSM), Av. Roraima, 1000, Prédio 7, Sala 306, Santa Maria, RS 97105-900, Brazil

## ARTICLE INFO

## Article history:

Received 30 July 2015

Received in revised form

18 December 2015

Accepted 27 December 2015

Available online xxx

## Keywords:

Educational game

Introductory activity

Motivation

Freshmen

Undergraduate

## ABSTRACT

This study evaluates the use of educational games as an introductory activity in the first year of undergraduate degree programs in industrial engineering. This proposal exploits the potential use of games to present complex situations without discouraging players, allowing new students to examine important elements of the professional field. Therefore, an educational game designed for use during the first year of classes was developed. The contribution of this game proposed for student learning and motivation was evaluated using a questionnaire, as was the receptivity to the use of educational games. The results show that this activity motivated students to participate and to better understand the course content. They also indicate that educational games are well accepted by the first-year students. The following benefits of educational games as an introductory activity in higher education contribute to these results: the opportunity to present different concepts in an integrated manner, the possibility of offering a comprehensive and dynamic example that can be shared by students and professors, the greater freedom afforded to the professor for individual interaction with students and the ability to simultaneously satisfy the demand for knowledge and motivation.

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## 1. Introduction

A challenge in engineering education is the ability to train students to collaboratively work to solve complex and poorly structured problems that involve technical and social aspects (Felder, Woods, Stice, & Rugarcia, 2000; Gattie, Kellam, Schramski, & Walther, 2011; Grasso, 2010). These needs emerge from the labor market, which seeks to satisfy new demands of society (Palma, de los Ríos, & Guerrero, 2012; Santandreu-Mascarell, Canós-Darós, & Pons-Morera, 2011). When the issue is the training of new professionals at the undergraduate level, learning how to articulate knowledge from different areas in the solution of real problems is

essential. In this case, one problem is to provide entering students with an integrated and contextualized view of the concepts covered throughout the course, in order to help them to understand the relationships among concepts from different areas during the training process. Another aspect to note is the perception that traditional teaching methods inefficiently capture the attention of students and engage them in academic activities (Coller & Shernoff, 2009). The involvement of students with academic activities positively relates to their notes and their duration at the university (Kuh, Cruce, Shoup, Kinzie, & Gonyea, 2008). As a result, new learning methods to promote an integrative vision and a motivated learning are valuable.

Therefore, the aim of this study is to evaluate the use of educational games as an introductory activity in the first year of undergraduate degree programs in industrial engineering. Presenting the different aspects of industrial engineering in an integrated manner requires complex and dynamic models, which require adequate means of representation. For its ability to represent complex and dynamic situations (Shaffer, Squire, Halverson, &

\* Corresponding author. Department of Industrial and Systems Engineering, Federal University of Santa Maria, Av. Roraima, 1000, Prédio 7, Sala 306, Santa Maria, RS 97105-900, Brazil.

E-mail addresses: [lynceo.braghirolli@ufsm.br](mailto:lynceo.braghirolli@ufsm.br) (L.F. Braghirolli), [ribeiro@producao.ufgs.br](mailto:ribeiro@producao.ufgs.br) (J.L.D. Ribeiro), [mail@adweise.de](mailto:mail@adweise.de) (A.D. Weise), [morganapizzolato@ufsm.br](mailto:morganapizzolato@ufsm.br) (M. Pizzolato).

Gee, 2005), this research make use of computer games to display a typical work environment of the industrial engineer to new students. Also, games are familiar to young people and, due to their potential motivation (Papastergiou, 2009), they can be a viable method for engaging new students in learning the concepts of industrial engineering, arousing interest and motivating students to learn the content throughout the course. Thus, in order to evaluate the use of educational games as an introductory activity, it is important to measure factors like the students' perception of enjoyment (Giannakos, 2013; Venkatesh, 2000) and students' perception of usefulness for learning (Ibrahim, Yusoff, Khalil, & Jaafar, 2011; Ong, Lai, & Wang, 2004; Venkatesh & Bala, 2008). In addition, digital games are linked to newer generations, but whether students are receptive to the use of these games in the context of university education should be assessed.

The next section presents a theoretical review of educational games by highlighting the arguments that justify the use of games in the academic context. The method employed in this research is described in Section 3. Section 4 presents the results and discussions on the learning, motivation and acceptance of educational games by first-year students. Section 5 contains the conclusions.

## 2. Related work

In the literature, various terms are used to describe educational games, such as digital learning games (Erhel & Jamet, 2013), game-based learning (Chen & Huang, 2013; Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012), edutainment games (Dondlinger, 2007; Moreno-Ger, Burgos, Martínez-Ortiz, Sierra, & Fernández-Manjón, 2008), persuasive games (Bogost, 2007; Connolly et al., 2012), epistemic games (Shaffer, 2006), instructional games (Garris, Ahlers, & Driskell, 2002) or serious games (Connolly et al., 2012; Muratet, Torguet, Jessel, & Viallet, 2009; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). Despite of the distinct nuance of each term, the discussions in the studies contribute to understand the utility of games for educational purposes. It is important to mention the distinction between games intended to entertainment, usually commercial off-the-shelf games, and games intended to learning (the term serious games emphasizes this aspect, see Connolly et al., 2012; Muratet et al., 2009; and Wouters et al., 2013). Although the player of an entertaining game need to learn something in order to progress in the game, the learning itself is not the main goal. On the other hand, the learning is the expected outcome of an educational game. We use the expression educational games in this work, referring to all games that are designed to facilitate the learning process while placing other goals in the background, such as entertainment.

A common aspect found in recent studies is the use of an electronic medium, like computers, to support games. Games are intrinsically related to education (Botturi & Loh, 2009), and not always rely on electronic medium (Sumukadas, 2010). Therefore, the educational games term include computer games designed for learning, but it is not limited to them. In this work, we focus on computer based educational games.

Simulation is the most common game genre in educational games (Connolly et al., 2012). Simulation games have the ability to represent real-life situations. They allow the player to act as managers, pilots, physicians, etc. in the game context. In this environment, the player can perform experiments with the simulated system (virtual character, environment or other models). However, a simulation game has to preserve some game elements, like challenge, conflict, fantasy, player's control, etc. (Wilson et al., 2009), to be considered a simulation game. Without game elements, we have simulations for training purposes only (Martens, Diener, & Malo, 2008). The reader is referred to Martens et al.

(2008) and Klabbers (2009a, 2009b) for a more detailed discussion about simulation and games.

The learning context of educational games includes formal situations in primary education (Baker, Habgood, Ainsworth, & Corbett, 2007; Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Ke, 2008), high school (Brom, Sisler, & Slavik, 2010; Kebritchi, Hirumi, & Bai, 2010; Papastergiou, 2009), higher education (Coller & Shernoff, 2009; Guillén-Nieto & Aleson-Carbonell, 2012; Ozcelik, Cagiltay, & Ozcelik, 2013) and graduate school (Wall & Ahmed, 2008) as well as in the professional environment (Guo, Li, Chan, & Skitmore, 2012). Educational games range from simple activities with repetitive practices (Orvis, Horn, & Belanich, 2008) to higher level learning, such as problem solving (Liu, Cheng, & Huang, 2011).

The use of educational games is supported by different learning theories (Dondlinger, 2007; Kebritchi & Hirumi, 2008; Wu, Chiou, Kao, Hu, & Huang, 2012). Learning theories based on behavioral conception perceive learning as an associative process, in which reinforcement serves an important role in changing observed behavior (Zimbardo, Johnson, & Weber, 2005). This conception of learning is evident in games that seek to exercise concepts and/or abilities by repetitive practice, see Ebner and Holzinger (2007), for instance. Conversely, games based on constructivist conceptions present other pedagogical arguments. One of the emphasized aspects is the importance of practical and concrete experience in the construction of knowledge based on the Theory of Experiential Learning (Kolb, 1984; Tuckman & Monetti, 2011). Games have interactive features (Wilson et al., 2009) and are capable of revealing the effects of particular actions, which enables new strategies to be established and tested. Also, they create a safe environment for experimentation, where the consequences of which are not transferred to the real world (Whitton, 2012). With the computational progress of recent decades, the games are now capable of providing experiences in contexts that are rich, complex, equipped with interactivity, and similar to real life. This experience is considered to be a source for the construction of knowledge, which is not simply transmitted but is obtained as a result of reflection on this interaction with the environment (Kolb, 1984; Tuckman & Monetti, 2011).

Another line of argument emphasizes the importance of the context in which learning occurs (Lave & Wenger, 1990; Vygotsky, 1978). Knowledge is assumed to be the product of activities and the culture in which they are developed and used. This notion implies that learning should be placed in this context and that the introduction of students to this context is part of learning. Thus, the development of skills and knowledge acquisition occur in the context in which they will be used with a goal that is relevant, meaningful and interesting to students (Kebritchi & Hirumi, 2008; Tuckman & Monetti, 2011). Ideally, this process of integration should occur in a real context; however, this outcome is not always possible, which renders the games a viable method to place students in these contexts. As an example, Tan, Tse, and Chung (2010) introduced the use of games for teaching concepts of lean production. The proposed game is the simulation of a company that manufactures seaplanes. Each company consists of four workstations where the products are manufactured. The workstations are managed by a group of students who assume the roles of production managers and operators. The goal of the game is to demonstrate the differences in performance derived from the changes in operating conditions. Based on the comparison of the results of a questionnaire administered before and after the game to 41 graduate students, the authors concluded that the activity produced a better understanding of the elements of lean production after the activity. According to Tan et al. (2010), in many cases, students cannot fully imagine a situation without being inserted into it. The games nurture the students' feelings of participation in a

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