



# Studying student differentiation in gamified education: A long-term study



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## ABSTRACT

Gamified learning is a novel concept that according to recent studies, can increase student activity and improve learning outcomes. However, little is known about how different students experience and are engaged by it. We present a long-term study which identified distinct behavioral and performance patterns in participants taking a gamified college course. Our study lasted for three years, during which we deployed three consecutive instances of the course, each featuring improvements based on student feedback from the previous instances. To understand how different students behaved in our gamified experience, according to their daily performance, we performed cluster analysis and assessed student engagement in the last year using a formal instrument. We then did a cluster-wise analysis using different performance and behavioral measures, to further assess and characterize every cluster. To wit, we identified six different student clusters, each featuring different behaviors and performance levels. However, only four were present in the last year, which differed in terms of engagement with the course. In this paper we carefully describe each student cluster, explain how they evolved, and derive meaningful design lessons.

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## 1. Introduction

Gamification is a recent concept that adopts game elements in non-gaming contexts (Deterding, Dixon, Khaled, & Nacke, 2011; Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011; Huotari & Hamari, 2012) to engage users and encourage them to adopt specific behaviors, such as being more ecofriendly (Inbar, Tractinsky, Tsimhoni, & Seder, 2011), becoming loyal to a brand (Zichermann & Cunningham, 2011), raising health awareness (Brauner, Calero Valdez, Schroeder, & Ziefle, 2013), improving productivity (Sheth, Bell, & Kaiser, 2011), or learning how to drive (Fitz-Walter, Wyeth, Tjondronegoro, & Scott-Parker, 2013). Gamification draws on the many motivational qualities of good games, which make them good behavior drivers and powerful learning tools (Bennett, Maton, & Kervin, 2008; O'Neil, Wainess, & Baker, 2005; Squire, 2011). As opposed to traditional educational materials, games can deliver information on demand and within context, and are designed to maximize choice and ease the impact of failure (Gee, 2003). Good games aim at preventing players from getting either

bored or frustrated, thus allowing them to experience flow (Chen, 2007; Csikszentmihalyi, 1991) and endure. Researchers and educators have for long been studying the effort and resilience of gamers when playing games, and how these can be put to use to help in learning (Prensky, 2002). Games have been used to educate with success (Squire, 2003; de Aguilera & Mendiz, 2003), with documented improvements in learning outcomes, motivation and diligence in different academic fields.

Gamification of education is a recent subject, and research shows promising results. Pioneer studies already demonstrate that gamification may potentially increase student activity (Denny, 2013, pp. 763–772) and performance (Domínguez et al., 2013), although replicating these results over several iterations of the same course seems to be unexplored. Furthermore, little information exists regarding how different students adapt to a gamified course and what kind of strategies they adopt. Recent works show that in a gamified setting, only users that bother to monitor their progress and that of others seem to be significantly affected by gamification (Hamari, 2013). Therefore, it is paramount to understand how different students play and learn in a gamified course and how they are engaged by it, to develop new gamification approaches that can adapt to their needs and engage more learners.

In previous work, we fully gamified a college course and

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observed that students participated more when compared to the previous non-gamified version of the course, and felt both more motivated and interested as compared to other “regular” courses (Barata, Gama, Jorge, & Gonçalves, 2013; Barata, Gama, Jorge, & Gonçalves, 2013, pp. 10–17; Barata, Gama, Jorge, & Gonçalves, 2015). We have now collected student data from consecutive terms of our gamified course, over a three-year period, where iterative changes took place to address students’ needs. We analyzed how they acquired experience points over time, via cluster analysis, and then made a cluster-wise assessment of different behavior and performance measures, including online participation, lecture attendance, evaluation results, among others. Furthermore, we also used a validated instrument to assess how each student was engaged with the course in the third year, and studied how this was portrayed to each cluster. Our study identifies six different student clusters, observed over the years, each exhibiting different behavior and performance traits. However, only four were present in the third instance of the course, where two of them were more engaged than the others. In this paper we carefully characterize each student cluster and study how they relate to each other. We also discuss how changes made to the course over the years may have affected their composition and how students from the third year differed in terms of engagement. We finalize by describing the most important lessons learned from this experiment and present guidelines for designers of gamified learning experiences.

## 2. Gamification in education

Games have long been considered good learning tools and their usage in education has been studied for more than a decade. Research shows that games can both be used to engage students and increase their activity and learning outcomes, at diverse academic levels, ranging from grade school (Lee, Luchini, Michael, Norris, & Soloway, 2004, pp. 1375–1378), through high school (Kebritchi, Hirumi, & Bai, 2008), to college (Coller & Shernoff, 2009), and in diverse fields of learning, such as numerical methods (Coller & Shernoff, 2009), biology (McClellan, Saini-eidukat, Schwert, Slator, & White, 2001), programming (Moreno, 2012), or electromagnetism (Squire, Barnett, Grant, & Higginbotham, 2004). Drawing on these pedagogical benefits, gamification was soon adopted in education to engage learners, with prominent examples being Khan Academy<sup>1</sup> and Codecademy.<sup>2</sup> In these services, students learn by watching videos online and performing exercises, while their progress is tracked via points and collectible badges.

Gamification applies game design elements to non-gamified processes (Deterding et al., 2011a; Deterding et al., 2011b). Even though there is not a formal list of elements to use, some of the most common are (Crumlish & Malone, 2009; Hamari, Koivisto, & Sarsa, 2014; Kim, 2008; Lewis, Wardrip-Fruin, & Whitehead, 2012; Werbach & Hunter, 2012; Zichermann & Cunningham, 2011): experience points and levels, serving the main purpose of transmitting feedback and progress; challenges or quests, which provide tasks with clear goals, progress assessment and train users for more complex tasks; badges, collectible artifacts that aim at boosting the user’s motivation by appealing to her natural desire to collect; and leaderboards, which spur competitiveness and encourage users to continually strive to achieve their desired ranking. Using leaderboards in gamification is controversial, given that users at the bottom usually become demotivated. However, research on leaderboards in gamified settings did not find any significantly harmful

effect on participant motivation (Aguilar, Holman, & Fishman, Mekler, Brühlmann, Opwis, & Tuch, 2013).

Measuring success of gamified learning has become a great concern. A major review on empirical studies on gamification suggests that effectiveness greatly depends on both context of application and the participants’ characteristics (Hamari et al., 2014). Another study tried to assess how effective gamification might be at motivating students, but formal measurements of intrinsic motivation do not support a correlation (De Schutter & Vanden Abeele, 2014). Still, gamification’s potential to shape student behavior is hard to overlook. We differentiate gamification applied to education into two different phenomena: 1) partially-gamified and 2) fully-gamified experiences. Whereas the former consists of typically gamifying a single evaluation component of a course (or other unit of teaching), the latter comprises the gamification of the entire course, changing how it is evaluated as whole.

There has been a lot of research in partially gamified learning. In their study, Cheong et al. used a gamified quiz to evaluate IT undergrad students (Cheong, Cheong, & Filippou, 2013), whereby they received points for answering questions and could then compare their scores with those of other students, in a leaderboard. Students self-reported that the quiz improved both their learning effectiveness and their grades, and also their enjoyment and engagement. However, this study presented no empirical results other than self-reports. Domínguez et al. also proposed a gameful approach to an e-learning ICT course (Domínguez et al., 2013), where students could take optional exercises, either by reading a PDF file or via a gamified system. In the latter, students were awarded with badges and medals by completing the exercises. They found that students using the gamified approach had better exam grades and reported higher engagement with the course.

Another work (Denny, 2013, pp. 763–772) studied the effect of adding badges to an online repository of student-generated multiple-choice questions. This was used to evaluate the students of a course featuring frameworks and tools to understand and control the impact of disease in populations. Students using gamification answered significantly more questions and were more active than those not using it. In a similar study (Hakulinen, Auvinen, & Korhonen, 2013), achievement badges were added to an online learning environment where students completed interactive automatically assessed exercises on data structures and algorithms. According to data collected from the system logs, achievement badges had a significant impact on student behavior, with more of them getting more perfect scores. However, only a small group of students was especially motivated to collect badges.

Fully-gamified learning focuses not on changing one evaluation component but in creating a whole new learning experience, where typically most evaluation components have to be adapted. In his book, Lee Sheldon (Sheldon, 2011) explains how a conventional course can be turned into a game, without using technology, where students start with an F grade and go all the way up to an A+, by completing challenges and gaining experience points. Several reported case studies using this method showed improvements that covered student attendance, willingness to participate and work, and grade performance. Following this approach, several other studies have reported encouraging and diverse findings. Aguilar, Fishman and Holman conducted a series of experiments with several gamified college courses (Aguilar et al., ; Aguilar, Fishman, & Holman, 2013; Holman, Aguilar, & Fishman, 2013), where they studied correlations between student perceptions of the gamified grading systems and adaptive outcomes associated with gameful course designs. The courses had comparable grading systems, where students had the freedom to specify the type of assignments and their respective weight covered by 60% of the grade. The remaining 40% respected to traditional criteria, like attending

<sup>1</sup> <https://www.khanacademy.org/>.

<sup>2</sup> <http://www.codecademy.com/>.

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