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Examining competitive, collaborative and adaptive gamification in young learners' math learning

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ABSTRACT

This paper presents the results of an empirical study conducted on three different types of gamified learning activities—namely competitive, collaborative, and adaptive—in lower primary mathematics classes. The participants were students from two second-grade and one third-grade classes who used tablet computers and digital learning lessons for learning mathematics. The study included a non-gamified and competitive, adaptive, and collaborative gamified conditions, which were integrated into lesson plans. The collected log data were used to calculate the changes in performance levels through the dimensions of task completion and time under each condition, and the data were further analyzed and compared across conditions. The quantitative analysis results were triangulated with interview data from the students. Overall, the results show that gamified activities contributed to increased student performance levels in math learning. Significantly higher performance levels appeared in a gamified condition combining competition, a narrative, and adaptivity with individual performance game elements. Although the highest performance levels appeared in conjunction with the most incorrect attempts by the students, the total number of correct attempts was unaffected. Our findings suggest that whether gamification works or not is not the result of individual game elements but rather the consequence of their balanced combination.

1. Introduction

Recently, gamification, which refers to the use of game mechanics and game elements in a non-game context, has attracted a significant amount of attention and has been applied in a wide range of fields in order to motivate to and engage people in performing certain activities and solving different problems (Kapp, 2012). Applications of gamification can be found in diverse situations and contexts, such as shopping, marketing, social networking, leisure, fitness, recycling, and learning (Tome Klock et al., 2015; Werbach & Hunter, 2012).

As an educational tool, gamification is used to facilitate learning, to encourage motivation and engagement, to improve learner participation and lesson interactivity, and to stimulate learners to expand their knowledge (Kapp, Blair, & Mesch, 2014). When implemented properly, gamification can increase intrinsic motivation and engagement (Villagrasa, Fonseca, Redondo, & Duran, 2014) and represents a powerful tool for teachers at all levels in the educational system (Buckley & Doyle, 2014).

Despite much interest and potential, however, the efficacy of gamification in education remains insufficiently explored (Hanus & Fox, 2015). Among the existing research studies, some have explored the use of gamification in context of the classic “pen & paper”

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learning process (Kuo & Chuang, 2016), while surveys involving digital gamification are often conducted involving university-level participants (Buckley & Doyle, 2014; de-Marcos, Garcia-Lopez, & Garcia-Cabot, 2016; Garcia, Copiaco, Nufable, Amoranto, & Azcarraga, 2015; Villagrasa et al., 2014) or as an extension of e-learning platforms (Domínguez et al., 2013; Muntean, 2011).

Some researchers argue that gamification alone is not sufficient to bring about the desired learning outcomes and that the efficacy of various game elements and their implementation need further exploration and empirical evidence (Hanus & Fox, 2015; Sailer, Hense, Mayr, & Mandl, 2017). In other words, they believe that additional empirical work should be conducted to identify efficient ways to implement different game elements that can increase learners' engagement, motivation, and performance. Furthermore, in gamification, it is agreed that one size does not fit all. While one game element (e.g., leaderboard) may work for some students, it could result in the opposite effect for other groups of students, even in the same class (Werbach & Hunter, 2012).

Recognizing the aforementioned challenges for incorporating gamification within educational contexts, this study explores the use of different types of gamification for young learners regarding their math learning processes and performance. In particular, we aim to contribute to the existing body of research concerning the impact of different gamification elements on learning. We concur with Sailer et al. (2017) that the notion of gamification is not a generic construct and that different design elements and game mechanisms can result in varying effects. To unpack the efficacy of different gamification types in learning processes and performance, we conducted a quasi-experimental study with three different configurations of gamification, namely competitive, collaborative, and adaptive gamification. Using a custom mobile learning platform and digital lesson authoring tools (Jagušt, Mekterović, & Botički, 2015), a series of experiments involving second- and third-grade primary school classes were conducted to compare the efficacy of gamification techniques on learning processes and outcomes in mathematics. In total, four sessions (referred to in the text as four experimental conditions) were conducted, each lasting for 15 min. Each session used a different gamification approach (i.e., competitive, adaptive, and collaborative) and implemented its own set of gamification elements.

The main research questions explored in this study were: (a) how do different types of gamification affect primary school students' performance levels and (b) how do game elements used in different conditions contribute to student performance in gamified activities? This study will also discuss the implications of using different gamification types as well as their drawbacks.

2. Theoretical background

Games are meant to be fun and entertaining and create desirable experiences even in less-interesting activities, thus increasing intrinsic motivation and making activities more enjoyable and engaging (Deterding, Khaled, Nacke, & Dixon, 2011, pp. 12–15; Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011; Kuo & Chuang, 2016; Monterrat, Élise Lavoué, & Sébastien George, 2014). Well-designed games can be used as learning tools that support deep and meaningful learning (Shute & Ke, 2012). Today, there is a prevailing consensus in the literature that so-called serious games (games whose primary objective is not mere entertainment) have a positive effect on learning process and outcomes by increasing engagement, interest, and immersion (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Hamari et al., 2016; Kapp, 2012; Kuo & Chuang, 2016; Poondej & Lerdpornkulrat, 2016).

The importance of games and play in human learning and personal cognitive development is rooted in Piaget's and Vygotsky's theories and has remained a subject of research (Nicolopoulou, 1993), resulting in the affirmation of the interdisciplinary field of game-based learning (GBL). GBL is specialized in exploring the connection and interaction between game and play and is described as a type of game with defined learning outcomes (Shaffer, Squire, Halverson, & Gee, 2005).

The term gamification was first coined in 2003 by Nick Pelling, a British game developer (Werbach & Hunter, 2012), and subsequently has gained broader recognition since 2010 (Deterding et al., 2011, pp. 12–15). The most commonly used definition states that gamification is “the use of game design elements in non-game contexts” (Deterding et al., 2011, p. 2). A more detailed and outcome-related definition states that “gamification is using game-based mechanics, aesthetics, and game-thinking to engage people, motivate action, promote learning, and solve problems” (Kapp, 2012, p. 83). Conceptually, gamification significantly differs from serious games and game-based learning in that, while serious games immerse learners into gameplay and strive to hide real educational objectives, lessons that are gamified have one or more game elements added (e.g., points, leaderboard, or badges), with the educational objectives clearly visible to users (Naik & Kamat, 2016; Plass, Homer, & Kinzer, 2015).

In recent years, a number of noteworthy gamification implementations and experiments were conducted, mostly targeting online and e-learning platforms and/or higher education courses. For example, Garcia et al. (2015) investigated the efficacy of a gamified educational environment for a programming course. They included typical gamification elements like points, leaderboards, and badges (the PLB triad) and found that students preferred using the gamified system to its non-gamified counterpart while simultaneously improving their performance in the programming tests. In another study, de-Marcos et al. (2016) compared educational games and social networking approaches to gamification and social gamification. Interestingly, their results stressed social gamification as the approach that yielded the strongest impact on students' learning performances. Similarly, an experimental design study that included 97 participants by Yildirim (2017) reported a positive impact of gamification on students' achievements and attitudes toward learning. Huang and Hew (2015) also concluded that gamification can be an effective tool for improving student participation, as well as encouraging extracurricular learning.

On the other hand, some researchers have reported mixed or negative results concerning the efficacy of gamification. For example, Frost, Matta, and MacIvor (2015) implemented a PLB triad with a storyline and the concept of lives into their learning management system, later measuring the levels of the desired outcomes. They concluded that, although students appreciated some gamification aspects, gamification alone did not have significant effects on the students' interest, motivation, or satisfaction levels. They interpreted this finding with the consideration of the nature of voluntary gameplay, in that gameplay is a voluntary activity, while the course in which they implemented gamification elements was obligatory; thus, by definition, there was no voluntary