Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness

S. Erhel*, E. Jamet

Experimental Psychology Laboratory, CRPCC, University of Rennes-II Haute Bretagne, 1 Place du Recteur Henri-Le-Moal, 35043 Rennes Cedex, France

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ABSTRACT

Although many studies have investigated the effects of digital game-based learning (DGBL) on learning and motivation, its benefits have never been systematically demonstrated. In our first experiment, we sought to identify the conditions under which DGBL is most effective, by analyzing the effects of two different types of instructions (*learning* instruction vs. *entertainment* instruction). Results showed that the learning instruction elicited deeper learning than the entertainment one, without impacting negatively on motivation. In our second experiment, we showed that if learners are given regular feedback about their performance, the entertainment instruction results in deep learning. These two experiments demonstrate that a serious game environment can promote learning and motivation, providing it includes features that prompt learners to actively process the educational content.

1. Introduction

Digital learning games have become a medium of reference in the education field over the past few years. Their popularity can chiefly be explained by the huge amount of leisure time that children and adolescents spend playing video games (Papastergiou, 2009a). However, the use of games to teach educational content inevitably raises the question of their compatibility with deep learning (Graesser, Chipman, Leeming, & Biedenbach, 2009). This has prompted many researchers to investigate the actual benefits of digital games, in terms of learning and motivation (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Gee, 2005; Prensky, 2001; Shaffer, 2006).

1.1. Digital game-based learning

Until very recently, studies of e-learning environments tended to focus on how to optimize the processing of information contained in multimedia or hypermedia documents (Clark & Mayer, 2008; Mayer, 2005). Now, however, researchers are starting to turn their attention to the effects on learning of a new medium: digital games. Digital game-based learning (DGBL) is a competitive activity in which students are set educational goals intended to promote knowledge acquisition. The games may either be designed to promote learning or the development of cognitive skills, or else take the form of simulations allowing learners to practice their skills in a virtual environment. Several authors have come up with definitions of DGBL. For Mayer and Johnson (2010), for instance, a DGBL environment should feature (1) a set of rules and constraints, (2) a set of dynamic responses to the learners' actions, (3) appropriate challenges enabling learners to experience a feeling of self-efficacy, and (4) gradual, learning outcome-oriented increases in difficulty. As Mayer and Johnson (2010) acknowledge, this is a very broad-brush definition, as it can apply just as easily to digital games as it can to traditional ones, such as chess. We gain a clearer idea of what DGBL is all about from the research conducted by Prensky (2001). For this author, one of the medium's key characteristics is the "coming together" of serious learning and interactive entertainment. In other words, digital learning games can be regarded as an entertainment medium designed to bring about cognitive changes in its players.

* Corresponding author. Tel.: +33 (0) 2 99 14 19 43.
  E-mail addresses: severine.erhel@univ-rennes2.fr (S. Erhel), eric.jamet@univ-rennes2.fr (E. Jamet).

1.2. Motivational benefits of DGBL

The benefits of DGBL, in terms of motivation and engagement, are often attributed to its entertainment aspect (Annetta, Minogue, Holmes, & Cheng, 2009; Hays, 2005; Lee & Peng, 2006; Lieberman, 2006; Moreno & Mayer, 2007; Rieber, 2005; Tobias & Fletcher, 2007; Tobias & Fletcher, 2008). According to Moos and Marroquin (2010), motivation corresponds to the set of physiological processes that influence the direction, vigor and persistence of behaviors. In their reviews of the literature on motivation in an academic context, Murphy and Alexander (2000), and subsequently Moos and Marroquin (2010), underscored the need to take several motivation constructs into account, in order to understand the complex mechanisms involved in learning more fully. To this end, Moos and Marroquin (2010) analyzed several studies of motivation, allowing them to identify the following construct categories: goal orientation, intrinsic-extrinsic motivation, interest, and self-efficacy. Taking learners' goals into account can help us understand the reasons behind their engagement in DGBL. The literature on goal orientation makes a distinction between mastery goals and performance goals (Ames & Archer, 1988; Pintrich, 2000). Mastery goals refer to the desire to develop skills or to master new knowledge or new sets of abilities (e.g., improving one's knowledge about a particular topic). Performances goals, on the other hand, refer to the desire to demonstrate one's ability to succeed, particularly by surpassing others while expending as little effort as possible (e.g., achieving the highest score in a game). This can be a particularly useful distinction in the case of digital games, as their entertaining and educational dimensions can prompt learners to focus either on performance goals (i.e., achieving the highest score) or on mastery goals (i.e., mastering knowledge).

A recent study reported a positive relationship between the level of intrinsic motivation and learning scores in a digital learning game (Liu, Horton, Olmanson, & Toprac, 2011). Intrinsic motivation refers to the inner desire to engage in a task out of interest or amusement, or even because of the challenge it offers (Deci & Ryan, 2000; Martens, Gulikers, & Bastiaens, 2004). Other studies of DGBL have looked at the relevance of flow theory (see Hays, 2005; Lieberman, 2006, for reviews). For Csikszentmihalyi (1988), the *flow* is the immediate subjective experience that occurs when an individual engages in an activity. This engagement, which can be likened to intrinsic motivation (Eccles & Wigfield, 2002), stems from a symbiotic relationship between the challenges faced by the individual and the skills needed to meet those challenges (Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003).

1.3. Benefits of digital learning games compared with conventional media (media comparison approach)

Many researchers agree that digital learning games have everything it takes to become an effective learning medium (Connolly et al., 2012; Moreno & Mayer, 2007; Prensky, 2001; Rieber, 2005). Over the past few years, a number of studies have sought to pin down the benefits of this medium compared with more conventional ones (Hays, 2005; Kebritchi, Hirumi, & Bai, 2010; Lieberman, 2006; Papastergiou, 2009a; Randel, Morris, Wetzel, & Whitehill, 1992; Tobias & Fletcher, 2007). Although results indicate that digital learning games are of debatable educational worth, the vast majority of researchers now acknowledge their benefits in terms of motivation and engagement. In a literature review of 68 studies, Randel et al. (1992) noted that just 22 studies comparing digital games with conventional classroom instruction concluded that games/simulations had a beneficial effect on learning performance. Nonetheless, the authors found that 12 of the 14 studies looking at motivation concluded that DGBL is more beneficial than traditional classroom learning. These findings, subsequently corroborated by a review of the literature undertaken by Hays (2005), were extended by Vogel et al. (2006), who demonstrated the learning benefits of digital games. In a meta-analysis of 32 studies, these authors found that educational games and interactive simulations had a positive effect on learning quality, compared with more traditional forms of teaching. Furthermore, learners displayed more positive attitudes toward learning methods based on educational games/simulations, than toward more conventional ones. More recently, however, an analysis by Kebritchi et al. (2010) has raised fresh doubts about the benefits of DGBL. Their analysis of 16 studies measuring the learning effectiveness of educational games and simulations revealed that only nine studies pointed to an improvement in learning quality compared with conventional lessons. Moreover, unlike previous reviews, it found that DGBL had only a weak motivational benefit. Just four of the 16 studies concluded that this medium increases motivational investment. A great many overviews have also expressed reservations about the use of DGBL (Connolly et al., 2012; Girard, Ecalle, & Magnan, 2013; Gredler, 2004; Lee & Peng, 2006; Lieberman, 2006; Papastergiou, 2009b; Rieber, 2005; Tobias & Fletcher, 2008).

The current state of the art does not allow us to conclude that educational games and simulations have a positive effect on learning and motivation. The results of studies comparing serious game environments (SGEs) with conventional media are still highly contradictory. Some authors believe that these contradictions stem from that fact that the effects of SGEs can be modulated by a range of different factors, including individual learner characteristics (Vogel et al., 2006), the learning situation (Ke, 2009; Vogel et al., 2006), and the topics being tackled (Hays, 2005; Ke, 2009; Ke & Grabowsky, 2007; Randel et al., 1992). For Clark (2001), Hays (2005), and Mayer and Johnson (2010), however, the contradictory results yielded by media comparison studies can chiefly be ascribed to the choice of methodology. Many authors have adopted a media comparison approach, measuring the learning outcomes of people who play an educational game against the learning outcomes of people who learn through conventional media. This methodology is vulnerable to many confounding factors (e.g., format, pace, educational content, teacher's social presence), which prevent us from clearly identifying the factors responsible for the benefits of DGBL. To avoid these methodological limitations, we favored another approach in our two experiments, namely the value-added approach (see Adams, Mayer, MacNamara, Koenig, & Wainess, 2012, for a recent example of this approach), which involves comparing the learning outcomes of learners receiving different versions of the same educational game.

1.4. Using instructions to improve the learning effectiveness of digital games

According to Graesser et al. (2009), DGBL imposes considerable constraints that "make it extremely difficult to integrate deep content, strategies, and skills" (p. 12). Even so, many researchers still maintain that this medium can allow good-quality learning. To prove their point, they generally apply a *value-added* approach to DGBL (see Adams et al., 2012, for a recent example of this approach), which consists in testing the effects on learning quality of adding features to an educational game. Although some authors have already adopted this perspective to examine the potential benefits of personalization (Moreno & Mayer, 2000; Moreno & Mayer, 2004), competition (DeLeeuw & Mayer, 2011), and self-explanation (Johnson & Mayer, 2010), to our knowledge, no one has so far subjected the games' instructions to scientific scrutiny,