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Is game-based learning better in flow experience and various types of cognitive load than non-game-based learning? Perspective from multimedia and media richness

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A B S T R A C T

The study examined differences on flow experiences and different kinds of cognitive loads (intrinsic, extraneous, and germane cognitive loads) between game-based learning and non-game-based learning groups. Participants were students of two classes taking a general education course, named *Life and Technology*, in a university. There were a total of 103 participants in the experiment: 50 students in one class (experimental group) used game-based learning materials; 53 students in the other class (control group) used non-game-based learning materials (webpage-based learning material). The results revealed that the game-based learning group significantly created more flow experiences than the non-game-based learning group ($p < 0.01$). The game-based learning group were significantly more interested, concentrated and able to control over their learning than the non-game-based learning group ($p < 0.05$). The game-based learning group had significantly lower extraneous cognitive loads ($p < 0.05$) and higher germane cognitive loads than the non-game-based learning group ($p < 0.05$). There were no significant differences in intrinsic cognitive loads between both groups. The relationships of flow experiences with intrinsic ($r = -0.239$; $p < 0.05$) and extraneous cognitive loads were negative ($r = -0.337$; $p = <0.01$). The relationship between flow experiences and germane cognitive loads was positive ($r = 0.202$; $p < 0.05$). Suggestions for educators, learners and future studies were also elaborated in the paper.

1. Introduction

1.1. Computer game and game-based learning

There are some features in computer games including fun, rules, goals, interaction, adaption, outcomes and feedback, win states, conflict/competition/challenge/opposition, problem solving, social interaction, representation and story (Prensky, 2007). These features can be used as the guidelines for designing games. Wouters, van Nimwegen, van der Spek, and van Oostendorp (2013) defined and described computer games were a set of interactive components and challenging activities based on a series of clear goals, agreed rules and constraints. Moreover, games frequently provide feedback as hints, records (e.g.scores) and changes to enable players to monitor their progress toward the goal. Competitive activities and stories are common and important in a computer game (e.g., adventure games), but they are not prerequisite of a computer game (e.g. action games). Prensky (2007) pointed out that playing digital game is an interesting and vivid activity, which enhances participants' interests, joyfulness, and motivations. As for game-based learning, it is an educational game that integrates learning contents and digital games to help players to learn about certain subjects. Prensky further defined game-based learning as a type of game that is designed to balance subject matter with gameplay and the ability of the player to retain, and apply the said subject matter to the real world. Game-based learning closely combines learning contents and computer games, which enhances the learners' learning interests and motivations.

1.2. Game-based learning and multimedia learning

In application of digital technology, multimedia is helpful to

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enhance learning performance including satisfaction, achievements, motivations, attention, and so on (Mayer, 2003). Traditional multimedia learning environments are built with two-dimensional space including texts, figures, images, and animations. On the other hand, game-based learning environments are presented by two- or three-dimensional space, including simulations, sense of presence, and high interactive features, which attracts learners' interests and attention. Simulation games immerse learners in observing, exploring and making decisions in a virtual world. Simulation games are interactive, in which player will feel more engaging than other learning methods. A high interactivity means the adequate communications between a computer and a player or between two players. Besides, a high interactivity is a critical element for effective learning and may result in learners' empowerment, ultimately enhancing their effectiveness (Sitzmann, 2011). A sense of presence is an on-the-scene feeling that participants experience in virtual worlds (Faiola, Newlon, Pfaff, & Smyslova, 2013; Schrader & Bastiaens, 2012). Hence, multimedia learning, without the integration of games, has less simulations and interactive features than game-based learning. Multimedia learning, embedded with features of games, can facilitate learners' attention and maintain their concentration for a longer period of time (Garris, Ahlers, & Driskell, 2002; Huang, Huang, & Wu, 2015; Papastergiou, 2009).

Gros (2007) suggested that multimedia learning, without the integration of games, tends to facilitate text comprehension, whereas learning with the integration of games tends to enhance the understanding of complex conceptions. Thus, learning with the integration of games allows learners to learn in a lively and vivid learning environment. Mayer and Johnson (2010) integrated computer games into multimedia learning in their study, and the results showed that a multimedia learning environment of a computer game helped learners more than a non-game-based multimedia learning or traditional learning environments. Pivec and Kearney (2007) pointed out that the integration of game with multimedia can provide momentums to learners, which make learning more efficient. Papastergiou (2009) found that in non-game-based learning, learners become bored and lack interest. Game-based learning can generate vivid interactions and facilitate students' learning motivations. Moreover, through gam-based learning, students will also have better learning achievements. In short, multimedia learning, integrating with games, can enhance students' learning motivations, achievements, satisfaction, as well as self-fulfillment, which is a future trend for education.

1.3. Game-based learning and flow experience

Csikszentmihalyi (1975) stated that the flow experience is a phenomenon where people enjoy and concentrate on an activity. Ghani and Deshpande (1994) believed that immersion generates concentration and enjoyment for people in an activity without outside interruptions. In other words, when people completely engage in an activity, they enjoy the immersion by filtrating irrelevant thoughts and cognitions; this is called the flow experience (Csikszentmihalyi, 1996). The flow experience includes clear goals, feedback, challenge-skill balances, a merging of action and awareness, a sense of control, concentration, time distortion, loss of self-consciousness, and rewarding experiences (Csikszentmihalyi, 1996; Hoffman & Novak, 2009; Kiili, de Freitas, Arnab, & Lainema, 2012). These experiences are exactly the processess of flow. Enabling participants to concentrate and neglect unrelated thoughts, the flow experience makes them feel pleased and satisfied, which is positive for learning.

Webster, Trevino, and Ryan (1993) proposed four constructs - control, focus of attention, curiosity and cognitive enjoyment. The constructs of the flow experience proposed by Pearce, Ainley, and Howard (2005) were enjoyment, engagement, and control. These constructs are concise and concrete, and hence they are suitable as a measurement for overall state of flow. Additionally, these constructs can be effectively presented by learner/player when they are pleased, engaged and self-controlled in a game activity (Csikszentmihalyi, 1975). Enjoyment refers that a learner/player enjoys the game activity. Engagement refers that a learner/player is engaged in and concentrated on the game activity. Control refers that a learner/player possesses a sense of control over the game activity.

A study done by Choi and Baek (2011) showed that a multimedia virtual learning environment enhanced levels of flow. Kiili (2005) explored learners' flow experiences toward games, and the results revealed that learners concentrated on learning and performed actively in a game-based environment. Kiili et al. (2012) found that simulation games could enhance university students' flow experiences, especially for a sense of control, clear goals, challenge-skill balances, rewarding experiences, and feedback. These experiences helped learners feel pleased and joyful. As for challenging tasks in game-based learning, if they are too simple, people would easily get bored; however, if they are too difficult, people would feel frustrated and disappointed. When the levels of difficulty in a challenging task match learners' skills, they may feel pleased and joyful (Csikszentmihalyi, 1996). Based on the perspective of game-based learning, Admiraal, Huizenga, Akkerman, and Dam (2011) evaluated learners' learning achievements and flow experiences. In their research results, they found that learners not only had higher flow experiences in games, but also comprehended learning contents more. Therefore, multimedia learning and game-based learning can effectively enhance learners' flow levels.

1.4. Multimedia learning and cognitive load

A cognitive load is a learning load where the amount or the presenting method of information exceeds a person's bearing capacity of the working memory. An appropriate amount of multimedia presentations lowers cognitive loads and enhances learning achievements. Kiili (2005) stated that multimedia learning usually results in better learning achievements, because processing information by visual and audio methods can simultaneously lower loads in the working memory. Sweller (2005) discovered that students learning with audio and texts simultaneously outperformed those who only learnt with audio; they also had lower cognitive loads.

Bartsch and Cobern (2003) argued that too many unnecessary multimedia learning elements would distract learners' attention and result in cognitive loads. Korakakis, Pavlatou, Palyvos, and Spyrellis (2009) found that three-dimensional animations enhanced learners' learning interests but increased their cognitive loads. Schrader and Bastiaens (2012) compared differences between a game-based virtual reality environment (three-dimensional environment) and a non-game-based virtual environment (texts and animations). Although the game-based virtual reality environment led to a high sense of presence, the results showed that it raised cognitive loads that interrupted students' learning achievements. Consequently, highly complex multimedia presentations can conversely generate cognitive loads and lead to an undesirable learning achievement.

The cognitive load mentioned above refers to the extraneous cognitive load, neither the intrinsic nor germane cognitive load. The intrinsic cognitive load relates to the loads generated from the levels of difficulty in teaching materials for learners, which is not easily altered by instructional designs (Sweller, Van Merrierboer, & Paas, 1998). The extraneous cognitive load is relevant to the loads