How Gamification Influences Immersive Learning Environment: An Affordance Perspective

Research-in-Progress

Wong Yee Man, Randy
Hong Kong Baptist University
rymwong@life.hkbu.edu.hk

Chan Kwan Yee, Joyce
City University of Hong Kong
isjoyce@gmail.com

Cheung Mei Kwan, Christy
Hong Kong Baptist University
ccheung@hkbu.edu.hk

Abstract

Virtual reality has received attention as an environment for learning, yet little is known about how the immersive virtual environment brings into university classrooms. Building upon prior literature on immersive technology, gamification, and affordance, we develop a model investigating how the gamification afforded by an immersive visualization system escalates students’ engagement, which in turn increases their learning motivation. We will test the model with undergraduate students who have experienced with a gamified immersive visualization system in the classroom setting. We believe that our work will enrich the existing literature on virtual reality in education and provide insight into the design of immersive representations and the structure of immersive learning paradigm.

Keywords: Immersive learning environment, gamification, gamification affordance, cognitive absorption, system satisfaction, learning motivation
Introduction

Over the recent decades, immersive technology breakthroughs—like virtual reality (VR) and augmented reality (AR)—have opened up stunning opportunities in various markets. Virtual reality, also known as immersive visualization, refers to a three-dimensional, computer-generated environment that simulates the physical presence of users in a virtual environment at a high level of realism (Zyda 2005). We have witnessed the rapid rise of the virtual reality. According to the latest statistics, individuals’ awareness of immersive technologies has almost doubled from 28 percent in 2016 to 51 percent in 2017 (Nielsen 2017). Several major companies such as Google, Microsoft, and Facebook have invested heavily in this technology, and the global immersive virtual technology market is expected to reach US$26 billion by 2022 (Zion Market Research 2017). Driven by the coming age of digital immersion, a surge of companies and educational institutions have recognized the transformative potentials of virtual reality for digital participation in education and training (Jung and tom Dieck 2017) and launched initiatives integrating immersive technologies with education (Freina and Ott 2015; Santhanam et al. 2016).

Immersive visualization system is an accessible and easy-to-use virtual reality technology that has been frequently used in higher education. It provides students with a learner-centered experience through creating a virtual environment that turns the digital scenarios into the engaging spatial environment. Specifically, students can not only experience the reality in a digital setting (i.e., experiential learning) but also interact with virtual objects and other users (i.e., collaborative learning). As a result, the use of the immersive visualization system in education can increase students’ engagement and improve their overall learning outcomes.

Although immersive visualization system presents huge opportunities for more effective and interactive learning experiences, prior studies have highlighted the difficulties in sustaining users’ engagement with an immersive visualization system and maintaining their motivation. When the novelty effect of the system is gradually reduced (Annetta et al. 2009), some students may lose their interests and become less motivated to engage with an immersive visualization system after their initial use, which in turn may affect their overall learning outcomes (Merchant et al. 2014). Thus, the use of immersive visualization system for promoting students’ learning motivation requires greater attention. Goel et al. (2013) suggested that when using technology to support learning, it is important to consider users’ satisfaction with a particular system, particularly, how the system design generates specific technological affordances that engage users in the learning process. Hence, we aim to understand the mechanisms that explain what factors motivate students to engage with an immersive visualization system in the classroom from the technological affordance perspective.

As effective learning in a virtual environment is closely tied to students’ interactions with IT artifacts in the environment (Goel et al. 2013), we believe that the perspective of gamification—the use of gaming mechanics in non-gaming contexts—can help to arouse students’ interest and keep them engaged with an immersive visualization system. The nature of gamified learning has been acknowledged in the computer-supported environments (Landers and Landers 2014). However, this perspective has not been explicitly applied to the context of learning through an immersive visualization system used in the classroom (Connolly et al. 2012). Therefore, it is necessary to gain more rigorous evidence of how a gamified immersive visualization system improves students’ engagement in learning.
To address the research gaps discussed above, we endeavor to answer the following research question:

**RQ:** How does a gamified immersive visualization system influence students’ engagement and learning motivation?

We expect that the results of the study will advance the understanding of gamification affordances in an immersive visualization system for learning and will help immersive technology developers, educators, and other practitioners identify the design features that can maximize students’ immersive learning experience. The remainder of the paper is organized as follows. In the next two sections, we introduce the theoretical foundation of this study and present the research model explaining how technological affordances of a gamified immersive visualization system facilitates students’ cognitive absorption, which in turn enhance their satisfaction with the system and increase their motivation in learning activities. Then, we outline the research methodology for validating the research model and hypotheses. Finally, we conclude with a discussion of the potential implications for both research and practice.

**Theoretical Foundation**

**Gamification**

Gamification is the use of “game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solve problems” (Kapp 2012, p. 10), which is a strategy that integrates the game mechanics and features with the principles of motivation and engagement to fuel the non-game activities and processes. It has emerged within various business sectors and has recently gained the notice of academics, educators, and practitioners in the domains of education and professional development (Seaborn and Fels 2015). For example, it has been employed to explain the phenomena of mobile banking acceptance (Baptista and Oliveira, 2017), continuous system use in workplace (Suh et al., 2017), etc. Several features of gamification have been applied to learning activities. For example, Denny (2013) investigated how a gamified feature in an online multiple-choice question-based learning system could be used to motivate students’ participation. Li et al. (2012) developed GamiCAD, a gamified tutorial system to help new users learn AutoCAD through missions, scoring, game levels, time pressure, mini-games, and rewards in the form of bonus levels. Notwithstanding the gamification attempts to harness the motivational power of gaming elements to promote participation, it remains challenging to fully engage students in learning activities. Immersive visualization system, however, excels at engagement. Immersive visualization system is inherently experiential that built from the ground up to convince students that what they see is real in order to create an engaging learning experience. Coupling with gamification, the immersive experience helps students to be fully engaged in the learning activities with an attractive and actionable task.

**Gamification Affordances**

Affordance refers to the combination of actual and perceived properties of an object, primarily in the perception of its possibilities for actions (Norman 1988). Affordance theory postulates that physical objects are associated with certain types of uses which influence individuals’ perceptions (Gibson 1986). In other words, the properties of an object are in terms of the possibilities it affords rather than the object itself. The term affordance is more about an object’s perceived utility. For example, a doorknob can be turned to open because the possibility of turning a doorknob to open is its affordance, while a button can be pressed because the possibility of pressing a button is its affordance.
The concept of affordance has been introduced to the studies in the virtual world (Goel et al. 2013), virtual reality learning environment (Shin 2017), gamified knowledge management system at the workplace (Suh et al. 2017), and Internet of medical things (Shin and Hwang 2017). We extend this idea and use the affordance theory to explain the role of affordance implemented in gamification that influences learning through immersive visualization system. The affordance lens is relevant and appropriate to be applied in this context because it allows us to assess students’ perceptions of technological artifacts while interacting with a gamified immersive visualization system for learning (Goel et al. 2013). Specifically, game artifacts as technological features can afford students the opportunity to experience game-like dynamics that make learning through the immersive visualization system more enjoyable, which, in turn, enhance their engagement and learning motivation.

Gamification affordances refer to an action that a user perceives as possible through the use of gamified systems (Suh and Wagner 2017). In a context where users interact with game artifacts (e.g., points, levels, badges or leaderboards), gamification affordances perform as the cues that enable users’ intrinsic or extrinsic outcomes, such as getting rewards, involving in competition or demonstrating expertise (Hamari et al. 2014). Suh et al. (2017) reviewed the prior studies of gamification affordances and proposed four types of gamification affordance, rewards, status, competition, and self-expression.

**Cognitive Absorption**
Cognitive absorption, refers to the state of deep involvement with technology use (Agarwal and Karahanna 2000), is derived from three closely related concepts: the trait of absorption (Tellegen and Atkinson 1974), the state of flow (Csikszentmihalyi 1990), and the notion of cognitive engagement (Webster and Ho 1997). The trait of absorption refers cognitive absorption as users’ personality trait of openness to the self-altering experiences (Tellegen and Atkinson 1974). State of flow describes it as “the state in which people are so involved in an activity that nothing else seems to matter” (Csikszentmihalyi 1990, p. 4), while the notion of cognitive engagement refers it as sustained attention to a task requiring mental effort, intrinsic interest, and curiosity (Scott and Walczak 2009). Agarwal and Karahanna (2000) proposed five dimensions, including temporal dissociation, focused immersion, heightened enjoyment, control, and curiosity, that describe the state of absorption, flow, cognitive engagement for capturing the holistic experience of IT use. Temporal dissociation is the inability to register the passage of time while engaged in interaction. Focused immersion is a state of total engagement where other attentional demands are essentially ignored. Heightened enjoyment captures the pleasurable and enjoyment aspects of the interaction. Control represents the user’s perception of being in charge of the interaction. Curiosity refers to the extent to which the experience arouses the user’s sensory and cognitive curiosity.

Prior studies have revealed the multifaceted roles of cognitive absorption in influencing IS use, particularly in the context of immersive technologies. For instance, Chandra et al. (2012) found that cognitive absorption plays a crucial role in determining users’ intention to use work-related virtual worlds. Goel et al. (2013) found that the state of cognitive absorption increases users’ learning outcomes in virtual worlds.

**Research Model and Hypothesis Development**
The gamification perspective coupled with the affordance theory highlights the importance of considering gamification affordances as the key determinants of users’ engagement with the IS (Suh et al. 2017). In this study, we propose that affordances of a gamified immersive
visualization system facilitate students to have meaningful interactions in the immersive learning environment that induce their state of cognitive absorption, which in turn influence their satisfaction with the system and also their motivation to learn. Figure 1 depicts our research model and hypotheses.

**Gamification Affordances In Immersive Learning Environment**

**Gamification Affordances and Cognitive Absorption**
Affordances induced by game elements allow users to have meaningful and deep interactions with the IS (Goel et al. 2013; Van Vugt et al. 2006). In this study, we adopt the four gamification affordances (i.e., rewards, status, competition, and self-expression) suggested by Suh et al. (2017) to investigate how the gamification affordances engage students with the immersive visualization system.

*Rewards affordance* refers to a property that allows students to obtain compensation by completing predesigned tasks. A well-designed reward structure of a gamified immersive visualization system, which includes both immediate reward-based feedback (e.g., points, badges and trophies), and constructive performance feedback (e.g., explanation for the achievement), enables students to focus on the learning tasks. The reward affordance offers students the pleasant feelings and stimulates their state of deep involvement while performing the designated activities through the immersive visualization system (Guo and Poole 2009).

*Status affordance* refers to a property that allows students to increase their level by achieving predefined goals or achieving milestones. Prior studies found that different levels of challenges are effective to keep users focused on a game, and to stay engaged and interested (Santhanam et al. 2016). Levels or milestones can show students their progress during the learning process (Seaborn and Fels 2015). A well-structured tiered level of a gamified immersive visualization system facilitates students to challenge themselves to reach higher levels, and thus enhance their perception of status affordances. When students reach a high level in a series of meaningful challenges, their state of enjoyment and control in the learning process will be heightened, which will make them easily immersed in the immersive learning.
**Gamification Affordances In Immersive Learning Environment**

**Competition affordance** refers to a property that allows students to compare their performance with those of others. Competition is an important characteristic of gaming that stimulates users to challenge one another in achieving the highest score in an activity, and keep players immersed (Deterding et al. 2011). In the context of immersive learning, competition plays an important role in sustaining or increasing students’ engagement and focus on the learning activities (Roussou 2004). Thus, we also expect that the higher the students’ perception of the competition affordance provided by a gamified immersive visualization system, the more they will immerse in it and the higher the state of deep involvement will be stimulated.

**Self-expression affordance** refers to a property that allows students to create unique selves. Self-expression affordance quantifies students’ immersive learning experience by enabling them to develop their own identities as well as affording their ability to express and differentiate their unique self from others in the learning processes (Suh et al. 2017). In the immersive learning process, students can earn badges or trophies, and reach higher levels to represent their self-improvement and accomplishment. This affordance of displaying achievements provides students a sense of self-fulfillment and meets their social need for achievement. Therefore, we expect that self-expression affordance enhances students’ sense of competence and control through using the immersive visualization system, which leads them immersed and focused on the learning activities and heighten their state of deep involvement.

Taken together, we propose the following hypotheses:

- **H1a**: Reward affordance is positively associated with cognitive absorption.
- **H1b**: Status affordance is positively associated with cognitive absorption.
- **H1c**: Competition affordance is positively associated with cognitive absorption.
- **H1d**: Self-expression affordance is positively associated with cognitive absorption.

**Cognitive Absorption and System Satisfaction**

In this study, cognitive absorption refers to a state of deep involvement with immersive visualization system for learning. System satisfaction, on the other hand, refers to the extent of positive response to the immersive visualization system resulting from students’ appraisal of the system as fulfilling or congruent with their needs for learning. Agarwal and Karahanna (2000) indicated that the cognitive absorption is highly associated with users’ positive responses to the system (i.e., perceived usefulness and perceived ease of use of the system). In this context, when students with a positive affective state of enjoyment that getting from the flow experience, they would be less likely to perceive cognitive burden during the system use (Chandra et al. 2012) and would express more satisfaction with the immersive visualization system. Prior studies also found that cognitive absorption while using an e-learning system (Roca et al. 2006) or a mobile learning system (Yu et al. 2012) has a positive effect on users’ satisfaction with the system. Therefore, we hypothesize that:

- **H2**: Cognitive absorption is positively associated with system satisfaction.

**Cognitive Absorption and Learning Motivation**

Learning motivation refers to the cause of students’ activities and interests which drives them to conduct and maintain their learning activities through the immersive visualization system. While the topics and the delivery of the content influence what students’ motivation to learn, it is the state of deep involvement with the immersive visualization system that influences their focus and level of effort expended on a given learning activity (Cole et al. 2004). Immersive visualization system offers a new mind-bending way for students to interact with the digital world. When students are immersed in an enjoyable learning activity they may also experience flow; their curiosity will motivate them to learn more through using the system. Thus, we argue that learning through the immersive visualization system increases students’ motivation if it
creates an enjoyable state of deep involvement to students during the learning process. Therefore, we hypothesize that:

**H3:** Cognitive absorption is positively associated with learning motivation.

**System Satisfaction and Learning Motivation**

Prior studies demonstrate that students’ satisfaction with the system can motivate them to learn (del Barrio-García et al. 2015). That is, working within a satisfying interface or system affords students a sense of autonomy and competence to engage in more cognitive processing learning activities (Sung and Mayer 2012), which in turn increase their learning motivation. In this context, the immersive and gamified features make students feel more satisfied with the display and interaction generated by the system and therefore become more motivated to work hard to learn. In short, students’ motivation to learn is highly associated with how well they are satisfied with the use of immersive visualization system in their learning processes. Therefore, we hypothesize that:

**H4:** System satisfaction is positively associated with learning motivation.

**Research Method**

**Data Collection**

We will test and validate the proposed research model with university students in Hong Kong. We have collaborated with universities which have applied the immersive learning system in their educational curricula. All respondents will be the actual users of a gamified immersive visualization system that is designed for facilitating immersive learning across subjects. A survey with longitudinal design will be conducted. Questionnaires will be administered to potential respondents at two points in time: after the initial usage of the immersive visualization system (T1), and the three months after the implementation (i.e., the last day of the class) (T2). The data collected will be analyzed with structural equation modeling.

**Measures**

We derived the measures for current study from prior literature with minor modifications to fit the context of an immersive visualization system for learning. Multi-item measures will be used for each construct to ensure the construct validity and reliability. The measures of gamification affordances (Suh et al. 2017), cognitive absorption (Agarwal and Karahanna 2000), system satisfaction (Au et al. 2008), and learning motivation (Nicholson et al. 2006) will be adapted from prior literature. All the measurements mentioned above will be phrased as questions on seven-point Likert scales, from *strongly disagree* (1) to *strongly agree* (7).

**Expected Contributions and Conclusion**

This study seeks to investigate how a gamified immersive visualization system engages students in the enjoyable cognitive involvement and keep them satisfied with the system and motivated to learn. The study is expected to make several contributions to both research and practice. First, this research will contribute to the literature by drawing scholarly attention to the gamified immersive visualization system in education. Second, the study will delineate a framework of how and why gamification engages learners with an immersive visualization system in a classroom. Specifically, we will investigate how the technological affordances of a gamified immersive visualization system can enhance students’ engagement and motivation in learning. Third, practitioners will also benefit from this empirical investigation. The technological affordances of a gamified immersive visualization system proposed in the study will help to determine the most desirable functions and features of an immersive visualization system that motivate students’ engagement with the system and their learning. In addition, the
results of the study will provide insights into the development of an ideal immersive gamified learning with immersive visualization that breaks the boundaries of formal education.

Acknowledgement
The work described in this article was partially supported by the Collaborative Learning through Immersion Project sponsored by a funding for teaching and learning-related initiatives in the 2012-2015 triennium from the University Grants Committee of the Hong Kong Special Administrative Region, China (Project No. CityU1/T&L/12-15).

References


