

論文内容の要旨

Engagement is at the heart of successful interactive products. Failing to engage users can lead to less participation, less learning, less sales, and other undesirable outcomes. Consequently, a product is not realized to its full potential. As O'Brien and Toms [35] have concluded - "Successful technologies are not just usable; they engage users."

Nevertheless, engaging users remains an ongoing challenge for designers and practitioners. Three challenges should be considered:

- the identification of engagement factors
- the prioritization of the factors affecting user engagement
- the evaluation whether the application of the factors can significantly increase participation and learning.

In this dissertation, we study user engagement through the lens of digital games. We are particularly interested of the quality of digital games to engage users in which may provide insights about general user engagement.

First, to identify and prioritize game engagement factors, we conducted two large-scale investigation studies - (i) a survey of existing engagement theories (Study 1) and (ii) a large-scale online survey study (Study 2). Second, to evaluate the effect of engagement factors, we conducted two empirical studies on gamification studying the application of engagement factors to learning (Studies 3-4), and two studies on full-body games studying player differences (Studies 5-6). See Figure 1 for the dissertation outline.

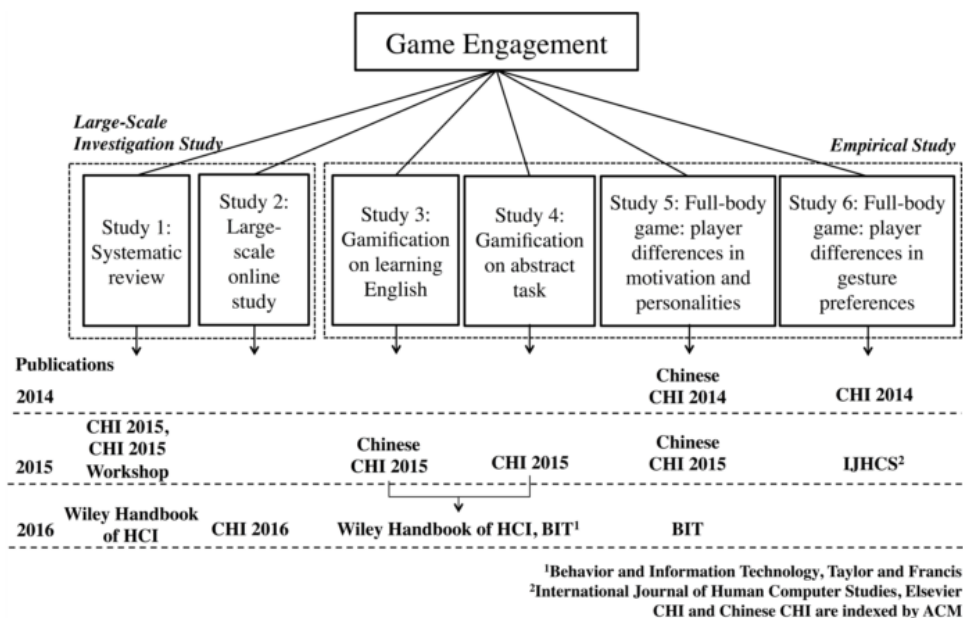


Figure 1. Outline of dissertation

LARGE-SCALE INVESTIGATION STUDY

We conducted two large-scale investigation studies: systematic review and large-scale online study.

Study 1: Systematic review

Engagement is at the heart of successful interactive products. It is also at the core of video games. Game applications for purposes, such as education, finance or health have attracted considerable interest recently.

However, development of these gameful applications is not adequately supported by knowledge of the fundamental mechanisms of game engagement.

On the other hand, there are many theoretical studies on game engagement scattered across different disciplines, but they have not been organized into a focused review of the fundamental mechanisms of game engagement.

To address this gap in knowledge, we synthesize and organize this scattered information regarding game engagement.

We conducted literature review using the systematic review methodology. The methodology consisted of four steps: (1) Identifying relevant databases and collections; (2) identifying relevant search terms/keywords; (3) specifying selection criteria and (4) perform data coding and analysis. We searched literatures from multiple disciplines including media psychology, game studies, HCI, social psychology, cognitive science.

Findings. Using grounded-theory approach on existing theories, we proposed a four-perspective framework of engagement: psychological (need satisfaction), affective (emotion), cognitive (cognition) and social (relationships). Using the framework, we identified two gaming motivations: Need Satisfaction and Emotion and identified two gaming outcomes: Absorption and Enjoyment.

Study 2: Large-scale online study

To explore game engagement from gamers' perspective, we conducted a Web survey to examine the motivation of gamers. We choose to conduct a Web survey because of its accessibility to large groups of diverse populations. This Web survey was intended to explore game engagement issues that may lie beyond our first study. It was also intended to assess patterns drawn from the first study. The Web survey was advertised on high-traffic game forums, which targets diverse gamers who regularly play games. We used open-ended questions to identify principles or factors that motivate gamers. Additional questions included demographic information.

To investigate the motivation behind gamers, our web survey focused on two aspects:

(i) engagement and (ii) disengagement of gamers. Both of these aspects of gameplay affect how gamers choose to play and engage in games and therefore provide a useful base from which to begin exploring game engagement. To examine these two aspects, we asked open-ended questions to the respondents.

A total of 203 participants from 26 countries participated. To identify patterns from the survey, frequency data were collected and measured. We used a text-mining

analysis approach to identify conceptual themes, based on grounded theory method (Glaser & Strauss, 1967). The approach extracted keywords from respondents' answers, and classify the themes by grouping synonymous terms with similar semantics (e.g., friends, team, community -> "Peer motivation"; role-playing, narratives, characters > "Story"), and to measure the frequency data by number of occurrences reported from unique participants.

Findings. Five major themes emerged as follows: (i) Story, (ii) Challenge, (iii) Peer motivation, (iv) Exploration, and (v) Aesthetics. Each theme reflects human's deep need for Autonomy, Competence, Relatedness, Purpose, and Emotional Arousal.

EMPIRICAL STUDY

We conducted a total of four empirical studies: two on gamification and another two on full-body games.

Study 3: Gamification effect on learning performance: A

quantitative study on English language

Motivating learners remains an ongoing challenge for researchers and practitioners in education. Gamification, with its potential to engage users, has received much interest from educators.

However, despite its growing popularity, there has been little evidence regarding the effect of gamification on learning.

This study studies the general effect of PBLs (Points, Badges, Leaderboard), the most common implementation of gamification, on learning. These game elements reflect essential game principles of progress, clear goal and competition.

This study used a between-subject design, comparing two learning system on teaching English articles – gamified and non-gamified system. Student's pretest-posttest comparison and subjective preference were measured.

Findings. The ANOVA results of our study suggest that PBL gamification has a clear positive effect on user performance and subjective preference. This proved our hypothesis that the augmentation of game mechanics can facilitate learning.

Study 4: Gamification effect on learning performance: A quantitative study on abstract tasks

Keeping learners motivated is a challenge in education. By contrast, games can easily stimulate players' interests and get them to commit time and efforts. A considerable amount of research has provided evidences that gamification, i.e., applying engaging game elements to other contexts can increase the users' desire to focus constantly on the task at hand and thus to improve their performance. In other words, people might be more motivated to participate in a gamified task. Researchers have identified many domains that may potentially benefit from gamification applications, such as business, healthcare, and education.

Despite the growing popularity of gamification applications in education, the effectiveness of game elements in this domain remains controversial. For example, some studies found it useful, while some showed no effect or even negative effects. This is because existing studies were often confounded by other factors, such as the nature of the task (e.g., learning subjects) or the quality of the materials (e.g., usability/interactivity). Previous research explicitly called for further investigation on generalizable conclusions and deeper understanding of gamification.

In this study, we fill the gap with empirical evidence from a controlled study on fundamental learning tasks that have been adapted from cognitive psychology, in order to remove possible confounding factors introduced by the use of specific learning applications. This approach was inspired by the Reductionism theory, a philosophical research approach that attempts to understand a complex set of phenomena through its simpler, fundamental elements. Specifically, instead of teaching a particular subject of study, we tested how well people can master and improve some of the basic cognitive capabilities required by the act of learning in various disciplines, such as the memory and problem-solving skills, using fundamental learning tasks. This allows us to investigate the effect of gamification elements on particular aspects of learning at a micro-level (e.g., gamification element A, B, C can improve the cognitive skill X, but not Y). Furthermore, this approach helps minimize possible complications introduced by the quality of the

materials or the user's personal interest/skills, and thus increases the overall generalizability of the results.

We used a between-subject design, comparing the effect of gamified (adding points, badges, and leaderboard) versus non-gamified interactive tools on assisting the acquisition of two fundamental skills of learning, i.e. memorization and problem-solving. In particular, we asked participants to complete three learning tasks for each skill (a total of six tasks). Each learning task targets a sub-dimension of the two learning skills (i.e., recall and recognition for memory; flexibility, planning, deductive reasoning for problem-solving). Based on the results, we derive a set of design implications for applying gamification in education.

Findings. An ANOVA comparison of the experimental group with the control group indicates that the presence of gamification has a clear positive effect on user persistence, attitude and performance. In addition, participants reported strong subjective preference towards gamification. This proved our hypothesis that the augmentation of game mechanics can significantly improve student persistence, attitudes, and learning performance.

Study 5: Full-body game interaction: Investigating player differences in motivation and gaming expertise

Full-body motion gestures enable realistic and intuitive input into video games. However, despite their intuitiveness, players may not always prefer full-body gestures for gameplay. Indeed, some players have reported that they did not enjoy full-body-based games even though they seem reasonably usable and natural. Without a clear understanding of player differences and how each different player envisages to enhance their gaming experience, it is difficult for designers to develop appropriate and effective full-body game interfaces.

Several studies regarding how body movement influences players during gameplay have been conducted. Yet, the different kinds of players and how they engage/disengage in full-body games remained unexplored. For example, in which context will players engage/disengage full-body games? In full-body game interaction, who are the primary targeted users? Are full-body games reserved for casual players only? How can designers better support the wide variety of players?

Understanding the rationale behind players' preferences could enable designers to develop more enjoyable and effective full-body game interactions.

To investigate these questions, adopting a user-typing approach, we explore player differences and their preferences in full-body game interaction. Specifically, we hypothesized three human factors that influence player's engagement, i.e., the player's *motivation to succeed* (achiever vs. casual player), *motivation to move* (mover vs. non-mover), and *game expertise* (gamer vs. non-gamer).

16 participants playing three different full-body games, a correlation analysis was conducted between player's differences and engagement data.

Findings. The results suggest a significant correlation and main effect of the three factors on players' engagement. The results also suggest three important game properties that affect players' preferences: level of cognitive challenge, level of physical challenge and level of realistic interaction.

Study 6: Full-body game interaction: Investigating player differences in gesture preferences

The introduction of Kinect-based interaction has enabled more natural and intuitive input for video games. However, game gestures designed by developers may not always be the most suitable for players. Indeed, players have reported difficulties in playing some motion-based games, particularly in interaction-intensive games (e.g., First Person Shooters/Action/Adventure) where several actions/commands have to be executed at or nearly at the same time. Thus one key challenge in game gestural interfaces lies in defining suitable gestures that enable players to effectively perform multiple game actions/commands simultaneously and with ease.

Though numerous full-body gesture studies have been conducted, little study has been conducted that consider the dynamic nature of game environments in general. When a player's hand is occupied with "Shooting Zombies", it is not known which other body parts and gestures players might prefer to perform simultaneous actions such as "Use First Aid Kit" or "Viewpoint Change". Since a literal "Jump" or "Climb" action can be tiring, we need to consider whether users might prefer less

tiring gestures. We would also do well to ask what gestures veteran gamers and non-gamers make or envisage to enhance their interaction experiences.

To investigate these potentials, this study analyzes how users define gestures for common game actions using user-defined approach. We also propose a novel choice-based elicitation approach.

Findings. Our study confirms the differences of gesture preferences between gamers and non-gamers. To accommodate this difference, we propose that designers should design multiple gestures for one action, when needed. We also suggest designers that they should allow end-user customization with gestures with low agreement score between participants. Other results include the identification of a suitable and alternative body parts for performing different games gestures. We also proposed a gesture set for simultaneous game interactions.