

Implementation of Game-Based Learning in a Tertiary General Education Course

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Abstract: Game-based learning can be an entertaining, engaging, and effective way of learning if both the game-play experience and educational content were carefully designed and balanced. By modifying an existing commercially available game rather than developing a game from scratch, the technical side and entertainment aspect of the game can be guaranteed so that educators can spend less effort in the technologies and game design but focus more on the educational and pedagogical aspect of designing and implementing game-based learning. We have enhanced a popular commercial computer game, Civilization, for use in a general education course that aims to nurture scientific literacy for tertiary students. The game has been used as a learning and assessment tool for this course along with other traditional course activities. The enhanced game includes scenarios which simulate world history and requires the players to lead a civilization and compete in these scenarios. Playing this 'mod' allows students to reflect upon, among many interesting issues, the dependency of scientific development on the political, economic, cultural, and geographical factors in history, which is one of the important intended learning outcomes in our course. The game has been used for 5 consecutive academic years. Survey responses and academic grades have been collected and analysed. The result is positive in both the rating on enjoyment and indicators of effectiveness of learning. Students who played the game are more engaged in course content, more willing to attend lectures and received a better course grade at the end as compared to those who didn't. While we cannot simply conclude with a causal relationship based on our reported analysis, we believe that playing this game is useful and suitable in complementing our traditional pedagogy. The engagement in game playing will increase, not decrease, students' effort spent on other traditional course activities.

Keywords: Game-Based Learning (GBL), Commercial-off-the-shelf (COTS), Civilization, Tertiary education, General education

1. Introduction

Game-based learning (GBL) is an educational approach that uses game content and game play as a pedagogy to achieve certain learning outcomes (Plass et al., 2015). Typically, GBL involves the design and use of an educational video game to support teaching and learning within a curriculum together with other traditional pedagogies (Perrotta et al., 2013; Shaffer et al., 2005). These games are sometimes considered as serious games with their primary goal being more than just pure entertainment (Michael & Chen, 2006), including the promotion of learning, attitude and behaviour change through playing (Dimitriadou et al., 2021; López et al., 2021).

GBL requires to strike a balance of covering the subject matter and prioritizing game play (Plass et al., 2015). By overcoming the challenges in the game, it provides learners with a sense of achievement while at the same time serving educational purposes. To achieve this balance, a good game design is necessary to make video games "fun", in the extent that games are neither too easy nor too challenging, so players do not feel bored or frustrated during playing (Admiraal et al., 2011). Game settings such as incentive system, game aesthetics, story narrative and game music are all important to keep players' interest in a game (Gee, 2003; Squire, 2013).

These games can facilitate three types of learning outcomes. The first is the development of specific knowledge, skills, and abilities (Kapp, 2012). Second, learners can also apply subject content to simulated real-world issues and develop generic skills, such as problem-solving skills, under the interactive nature of serious games (Dimitriadou et al., 2021). Third, GBL can promote positive changes in attitude, behaviour and emotions towards the course content (Sandí-Delgado et al., 2022). For achieving these learning outcomes, GBL should be designed in accordance with contemporary learning theories with a successful game design (Qian & Clark, 2016; Young et al., 2012). The theories can be explained in three major perspectives correspondingly, namely cognitive, sociocultural and behaviour/motivational perspectives (Plass et al., 2015).

Cognitively, learning from video games is mediated by engaging appropriate cognitive processes to shape cognitive development and learning (Tobias & Fletcher, 2014). Playing can be considered as a learning environment that is motivating yet lots of information is to be processed by the learner. The process provides gamers with repeated opportunities to practice skills and apply knowledge, ending up transferring knowledge from the game to reality (Plass et al., 2015). More educational games are developed with a view to learning in an interactive means for knowledge acquisition (Perrotta et al, 2013).

Good educational game allows players to enter the cognitive state of “flow” (Csikszentmihalyi, 1990; Plass et al., 2015). Flow is a concept from positive psychology which brings players to the intense, sustained and focused engagement to achieve a goal with pure pleasure rather than external rewards. Players attain a state of concentration to focus on the activity, which can be achieved with moderately challenging tasks and instant feedback (Nakamura & Csikszentmihalyi, 2014). Players in the state of flow are beneficial to talent development and academic performance while at the same time meaningfully engaged in the learning process (Csikszentmihalyi, 1990; Coller & Shernoff, 2009). The state of flow creates the optimal experience for individuals to master their skills and engage themselves in the activities (Csikszentmihalyi, 1990). To achieve flow, Csikszentmihalyi proposed that there are eight elements as the conditions: A challenging but tractable task to be completed; one is fully immersed in the task; one feels fully in control; one has complete freedom to concentrate on the task; the task has clear unambiguous goals; one receives immediate feedback on actions; one becomes less conscious of the passage of time; sense of identity lessens, but is afterward reinforced, which are common among people with optimal experiences, and these eight elements can be achieved in educational games to guide players entering into the state of flow (Cowley et al., 2008).

From the sociocultural perspective, video games provide rich contextual information and social interactions that improve learners’ understanding of social norms and emotional recognition (Plass et al., 2015). Students can develop a comprehensive understanding of the world from different angles under role-playing simulating games (Squire, 2005). Also, by closely mirroring real life or simulating a scenario, learning can take place in a socially and culturally structured virtual world by providing information to the learners at the precise moment, to exercise their problem-solving skills to some of the simulated real-life issues (Plass et al., 2015). Acquisition of soft skills such as collaboration, problem-solving, imagination and creativity are all present in video games, as many of the multi-player games require high order thinking skills to overcome the challenges and achieve the final goal (Yang, 2012). There can be wins and losses in video games, yet video games allow graceful failure as the lowered consequences of failures in games encourage risk taking, skills development and receiving positive feedback, so players are more motivated to continue exploring new things (Plass et al., 2015; Hoffman & Nadelson, 2010). Failure is sometimes expected and designed as a way for players to reflect on their strategies, thinking how to overcome the challenges to achieve a specific learning goal, in turn learning from their mistakes and facilitating the learning process (Kapur, 2008). The role-playing nature of many video games also allows learners to explore various social roles inside and outside of the game, forming new ideas and testing them to develop independent thinking (Squire, 2005). Learners can immerse themselves in a setting highly resembled the real world, easily setting up a learning community and transforming learning from the stage of “learning by being told and doing” to “learning by playing a role and becoming one” (Twining, 2009; Qian & Clark, 2016).

Motivationally, well-designed video games also stimulate players to engage in the learning process and to focus better on studies than traditional learning approaches (Dickey, 2005; Whitton, 2011). These video games are capable of engaging and motivating players by providing experiences they enjoy; thus, they are eager to continue the interaction (Gee, 2003; Krath et al., 2021). With the same rationale, educational games motivate players to pay close attention to game details, fostering their cognitive processing of the contents and thereby improving learning.

GBL could also lead to greater student engagement and participation in other course activities if implemented correctly. A positive influence on lecture attendance has been observed as students found the gamified course content more interesting and motivating to learn (Barata et al., 2013). Sailer & Homner (2020) performed a meta-analysis to statistically synthesize the existing research on the effects of gamification on cognitive, motivational, and behavioural learning outcomes, with positive findings as well.

2. Methodology

We shall now explain how we adopt GBL in a tertiary general education course that the author of this paper taught for the last 10 years. This course, called “In Dialogue with Nature”, is one of the two seminar courses in the General Education Foundation Program, which is a common core requirement for all undergraduates in the Chinese University of Hong Kong. The course is concurrently taught by 13-14 lecturers. Each lecturer teaches around 150 students in each semester. This course aims to nurture students’ scientific literacy and requires students to read excerpts of many science-related classics as core texts (Chan et al., 2012). One of the core questions in this course is to discuss the so-called “Needham’s grand question”, which can be phrased as “why had modern science not developed in Chinese civilization?” (Needham, 2004). While there is unlikely a direct answer to this question (Sivin, 2005), reflecting upon the historical settings, dependencies of scientific

development and scientific revolution allow students to have a more comprehensive understanding of what science really is.

The course has been well received by the students (indicated in the course evaluations conducted in each semester) for it being intellectually stimulating. However, students often find the core readings in this course challenging and difficult to comprehend. They also find it hard to situate themselves in the respective worldviews of the core texts. These could be due to the lack of reading confidence, insufficient understanding of background knowledge and the difficulty of visualizing the complex historical setting. Considering this, several e-learning tools were developed to assist students in this course (Kiang et al., 2016). In particular, a popular commercial game called Civilization (version 4 and subsequently 5) was adopted for GBL by the author, as one of the lecturers in this course, for his own class.

2.1 Commercial Off-The-Shell (COTS)

It should be noted that developing a sophisticated game that can achieve all the effects mentioned in the introduction is not an easy task. We avoided developing from scratch and have investigated the possibility of adopting commercial off-the-shelf (COTS) game at the beginning. COTS games are created by companies for entertainment purposes. These companies usually would know better than teachers on how to make an effective and engaging game to attract players (Van Eck, 2009; Charsky & Mins, 2008). While these games were not designed for educational purposes, a commercial game can still be used if it is designed to be a serious game, which usually provides intellectual challenges or rich in contents (Charsky & Mins, 2008). The most popular approach to using COTS games for education is to enhance the existing game with more specific educational content using the tools provided by the game. This is the most cost-effective in terms of money and time and maximizes the quality of the game used (Van Eck, 2006). COTS games cover a wide range of areas like math (e.g., the Sims series), history (e.g., Civilization), or science (e.g., Contraptions). The challenging nature of the COTS games also teaches students problem-solving skills if they play these games over long periods of time (Van Eck, 2009).

Built on the above concepts, the author has selected the game Civilization for GBL in *In Dialogue with Nature*. The game Civilization is a world simulator. A player can lead a chosen civilization starting from 4000 BC until 2050 AD to compete with other civilizations for land and resources and develop one's own civilization into a scientific, military, religious or cultural leader in the world. We think that this game provides enough opportunities and challenges to allow students to enjoy, enter the state of "flow", exercise their critical thinking and learn from their mistakes. We have purchased 200 game licenses (first in Civilization 4, and then subsequently Civilization 5) and obtained the written consensus from Firaxis (the company which developed the game Civilization) to allow students in each semester to use the licenses for the educational purposes mentioned in this paper.

The author has modified the game (using mostly the development tools that comes with the game) include adding two new scenarios that simulate the geographical landscape of the real world (plain world map starting at 4000 BC) and the historical setting in 1500 AD. Playing this 'mod' allows students to reflect upon, among many interesting issues, the dependency of scientific development on the political, economic, cultural, and geographical factors in history, which is one of the important intended learning outcomes in our course. We also asked our students to play the 1500AD scenario twice, once as a Western civilization and once as an Eastern civilization, so that he/she can compare their scientific development to generate their own reflection on the Needham's question. The "mod" for Civilization 5 is made publicly available on Steam, a widely popular gaming platform, for everyone to use (Kiang, 2018).

Playing the game is structured as an optional assessment as it may not be the cup of tea for all students (Whitton, 2011). Students can freely decide whether they want to play the game or to participate in online written discussions facilitated by Blackboard discussion forums. Both options are structured under the assessment component called "outside-class student participation", which is worth 10% in the assessment scheme of this course. The other assessment components in this course are in-class participation (16%), quizzes (24%), and essay writings (50%). We shall now present the evaluation results of this GBL implementation in the next section.

3. Evaluation and Discussion

3.1 Students' Perception of GBL

Students' opinions towards the two learning activities, namely playing the game Civilization and Blackboard online discussion, have been collected via surveys for five consecutive academic years (from 2016-17 to 2020-

21)¹. There are in total 1111 student respondents, with 485 students participated in online discussions and 626 students experienced GBL in this course. In general, feedback from the students about these learning activities is generally positive, with all the survey items scoring higher than 3, the neutral rating of the 5-point Likert scale used (Table 1). By comparing the two groups, independent-sample T tests are conducted, determining if there is any statistical significance between the population means of the two groups. The scale of $p < 0.05$ is used to indicate any statistical significance observed.

The data shows that the game is considered a more effective learning tool, as more student respondents agreed that it increases their interest in course issues (game = 3.99, discussion = 3.33), helps students understand fundamental concepts in the course (game = 3.87, discussion = 3.56), is enjoyable to participate in the activity (game = 4.20, discussion = 3.64), is helping in learning (game = 3.94, discussion = 3.69) and is convenient for students to join (game = 4.24, discussion = 4.01) (Table 1). Playing games as a learning activity revealed itself to be a more popular and enjoyable one for students.

Table 1: Students' satisfaction with learning activities (Mean value in a 5-point Likert scale)

Survey item	Game	Online Discussion
[The activity] increases my interest in course issues*	3.99	3.33
[The activity] help me understand fundamental concept in the course*	3.87	3.56
Overall, participating in [the activity] is enjoyable*	4.20	3.64
Overall, participating in [the activity] is helpful in learning*	3.94	3.69
The current setting for [the activity] is convenient*	4.24	4.01

* $p < 0.05$ for the two-group comparison under two-tailed t-test

In parallel with the student surveys, focus group interviews have also been conducted in the first academic year (2016-17) in the 5-year period. Students' verbal comments related to the games reinforced the above quantitative findings. In general, student respondents stated that the game-based learning experience inspired them to think about the course materials and connect what they had learned. Representative quotes are listed below (originally recorded in Cantonese, translated to English by the authors):

"The game allows me to re-evaluate my thoughts on civilization development, and I started to realize the importance of several factors, such as scientific progress and population growth, that are crucial for the prosperity of countries."

"Through playing the game, we can observe how a civilization develops and their scientific development at any given time frame. As scientific research grows slower in some countries, this echoes the viewpoint from the text that science may not develop well in every civilization."

"By playing the game, I realized that there are weaknesses in certain civilizations that hinder their development as reflected in history. This part tells me more about the importance of science in the history of humanity."

"When I was reading the required text about the scientific development of China, I did not have any clues about the impacts on people's daily lives, and it is hard to compare the scientific progress of different countries. From the game, I discovered that the Western civilizations have the edge over China in terms of scientific progress, leading to the early modernization of the Western countries."

"The game provided a great chance to become aware of issues a state leader has to deal with, such as resolving the shortage of food, addressing citizens' needs, and preventing the overthrow of the government. Economic problems and military threats are the top priorities for state leaders."

"In order to win the game, we have to actively reflect on their development strategy, figuring out the possible reasons that some civilizations are underdeveloped, and the solution to it. Such a thinking practice can nurture our critical thinking and problem-solving skills."

¹ The data for the first semester of 2019-2020 academic year is missing due to the social unrest in Hong Kong.

3.2 Self-Perceived Attainments of Learning Outcomes

We also would like to measure how GBL contributes to students’ attainment in the course as a whole. Instead of directly asking questions about the game or the online discussions, we have also asked several questions related to the course learning outcomes, but NOT specifically related to either of the two outside class activities. Comparing the results from the two groups shows that the game group gave higher ratings in self-perceived attainments of the learning outcomes in this course (in a 6-point Likert scale). These include: their interest in natural science (game = 4.57, discussion = 4.37), acceptance in scientific knowledge as important for their intellectual development (game = 4.89, discussion = 4.73), understanding the development in natural science (game = 4.60, discussion = 4.48), understanding features of scientific methods (game = 4.74, discussion = 4.61) and understanding the contributions and limitations of scientific inquiry (game = 4.81, discussion = 4.71) (Table 2).

Table 2: Students’ self-perceived attainments (Mean value in a 6-point Likert scale)

Survey item	Game	Online Discussion
I am interested in natural science*	4.57	4.37
Scientific knowledge is important for my intellectual development*	4.89	4.73
I understand the development of natural science*	4.60	4.48
I understand various features of scientific methods*	4.74	4.61
I understand the contributions and limitations of scientific inquiry*	4.81	4.71

* p<0.05 for the two-group comparison under two-tailed t-test

3.3 Objective Evaluation - Course Grade

Apart from collecting evidence about students’ interest and self-perceived attainments, we have also collected and analysed their course grades as an objective evaluation in their attainments. Our findings indicate that students choosing to play the game as their learning activity performed better than those choosing online discussion, with their course grade points (e.g. A = 4.0, A- = 3.7, B+ = 3.3, B = 3.0, etc) being 3.236 and 3.180, respectively (Table 3).

To avoid the doubt of self-selection bias (i.e. better students select to play the game), we put these grade points under a benchmark. We collected and deducted the students cumulative grade point average (cGPA) in their previous studies in the university before taking this course. This allows us to have a proxy to measure only the “gain” in grade point in this course, assuming students would otherwise obtain their usual performance in this course. Interestingly, the cGPA of the game group scores lower than the discussion group on average, 3.120 and 3.175 respectively. By deducting the grade point in this course by their cGPA, there is a 0.116 grade point gain in the game group while there is negligible grade point gain (0.005) in the discussion group. The difference of the two is statistically significant. This result seems to suggest that GBL is effective to lift students’ academic performance in this course, as compared to using written online discussion, a more traditional pedagogy.

Table 3: Students’ academic performance

Survey item	Game	Online Discussion
Students’ course grade (over 4)	3.236	3.180
Students’ cGPA before enrolling the course (over 4)*	3.120	3.175
Course grade – cGPA*	0.116	0.005

* p<0.05 for the two-group comparison under two-tailed t-test

3.4 Course Engagement

A typical challenge raised against GBL is that playing games might easily distracted students from their “proper” coursework. While this also relates to the stigmatization of playing games as “time wasting” or “not educational”, it is still a legitimate worry whether playing the game would compensate their time in other learning activities. Table 4 presents the relevant survey data in this regard. Our finding shows that, students

spent significantly more time playing the game than those in the online discussions (game = 10.41 hours, discussion = 4.41 hours). However, students in the game group spent a similar amount of time (no statistical significant difference) on course reading (game = 2.37 hours, discussion = 2.40 hours) and writing reflective journals (game = 7.28 hours, discussion = 7.19 hours). Moreover, the attendance rates of lectures (game = 71.3%, discussion = 69.7%) and tutorials (game = 84.9%, discussion = 86.2%) for both groups are also similar, indicating that spending more time playing the game does not necessarily deter students from other learning activities in this course. It is suggested that when students are more motivated to learn, they would be more willing to spend time in the course. Hence, using GBL together with traditional learning activities may not be a zero-sum game. If students find the game interesting, they would compensate more of their leisure time voluntarily to the course, rather than necessarily giving up in other learning activities.

Table 4: Students’ lesson participation rate and efforts spent on different learning activities

Survey item	Game	Online Discussion
Hours spent on game or discussion*	10.41	4.41
Hours spent on reading each required course text	2.37	2.40
Hours spent on writing each reflective journal	7.28	7.19
Lecture attendance	71.3%	69.7%
Tutorial attendance	84.9%	86.2%

* p<0.05 for the two-group comparison under two-tailed t-test

4. Conclusion

GBL can be beneficial to education if implemented carefully. A good balanced educational game can facilitate students’ development of specific knowledge, generic skills and improve their motivation in course learning. We have reported our implementation of GBL, using the COTS game Civilization, in a tertiary general education course. We modified the game using mainly the tools provided by the game to enhance the aspects related to the specific knowledge of this course. Students can optionally choose between playing this game or participating in online discussion as an assessment component. Results showed that for those who participated in the game enjoyed the game more than those participated in online discussion. The game group also rated higher in their self-assessed achievement towards the course learning outcomes. More importantly, the objective evaluation via grade point analysis showed that the game group performed better than the discussion group. There was a significant difference in the time they spend on the two activities, but there was no significant difference in their time spent on other course activities (lecture and tutorial attendance, time spent on reading and writing). While we cannot simply conclude with a causal relationship based on our reported analysis, we believe that playing this game is useful and suitable in complementing our traditional pedagogy in this course. The engagement in game playing will not decrease students’ effort spent on other traditional course activities. It is hoped that our findings highlighted the effectiveness of GBL in helping students to learn and arousing their interests in tertiary education.

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