Gamification in Education: A Proposed Study

**Introduction**

Gamification can be generally defined as “the use of design elements characteristic for games in non-game contexts” (Deterding, Dizon, & Khaled, 2011, p. 13). As the frequency of human-computer interactions continue to increase throughout all aspects of life, gamification has grown in popularity as a way to utilize the benefits of traditional game-playing. Therefore, this process lies at the intersection between computer science and psychology. While technical skills are necessary to evaluate the feasibility of a game design and actually create the game, psychological skills are necessary to understand the various motivations involved in a game’s design and make educated predictions on how certain design choices may affect a player.

But does gamification actually work? A review by Hamari and colleagues suggests it does (Hamari, Koivisto, & Sarsa, 2014). However, its efficacy seems to depend somewhat on the context and population with which the intervention is attempted on. Hamari’s 2014 paper splits the concept of gamification into three main subsections: 1) motivational affordances, 2) psychological outcomes, and 3) behavioral outcomes. Motivational affordances essentially refer to the game design elements that are being implemented with the intention of motivating user behavior in some capacity. These include points, leaderboards, achievements, and more. Psychological outcomes are often looking at measures such as reported motivation, engagement, and enjoyment. Lastly, behavioral outcomes were operationalized with measures such as test scores and completion percentages. Hamari reports that the majority of studies included in their review showcased positive psychological and behavioral effects from the gamification intervention. However, they also point out that there can be some drawbacks, particularly in school settings, where the increased competition from leaderboards and badges can have adverse consequences.

Gamification’s efficacy is driven by the idea that game design elements can be used to motivate user behavior. However, the actual mechanisms undergirding this motivation are often underexplored. A paper by Sailer and colleagues aims to begin investigating how exactly game design elements satisfy the psychological needs of players (Sailer et al., 2017). They utilize the self-determination perspective of psychological need satisfaction, which splits psychological needs into three divisions: the need for competence, the need for autonomy, and the need for social relatedness. Sailer then matches common game design elements to these divisions, addressing competence with points, badges, and leaderboards, addressing autonomy with decision freedom and task meaningfulness, and addressing social relatedness with avatars, immersive stories, and NPCs (non-player characters). Following these groupings, they developed a simple storage depot game that tasked players to completing five different orders. Experimental condition one utilized badges, leaderboards, and a performance graph, while experimental condition two utilized avatars, a meaningful story, and teammates. After their experience playing the game, participants took a psychological need satisfaction questionnaire. As hypothesized, condition one had an increased competence need satisfaction, while condition two had an increased social relatedness need satisfaction. This study is just the start of our continuing understanding of the important psychological mechanisms at play driving motivational gameplay.

Gamification has a wide breadth of potential applications. One of the most common uses is in schooling or other educational settings, where game design elements can be used to make the learning experience more fun and engaging for kids (Denny, 2013; Domínguez et al., 2013; Li, Grossman, & Fitzmaurice, 2012; Alshammari, 2020; Turan et al., 2016; Hursen & Bas, 2019). The business world also utilizes gamification to influence user behavior in contexts such as apps and websites, including boosting response quantity on help forums like StackOverflow (Grant & Betts, 2013; Anderson et al., 2013; Gustafsson & Bång, 2008; Halan et al., 2010; Montola et al., 2009). Some other promising avenues of research that are less populated in the current literature are applications in work settings and making tedious tasks more enjoyable. For example, Farzan and colleagues added a point system to an opt-in social networking site for employees that resulted in an initial surge of contributions to the site (Farzan et al., 2008). Additionally, Flatla and colleagues found that gamifying machine calibration resulted in participants reporting the typically monotonous task to be significantly more enjoyable (Flatla et al., 2011).

One of the recurring critiques of the expansive gamification literature is researchers’ tendencies to strip game elements down to their bare bones and attach them to a task, declaring that task as gamified. As Gallego-Durán and colleagues articulate, there is a barrier preventing many researchers from properly understanding gamification principles that resides in the difficulty of creating truly entertaining games (Gallego-Durán et al., 2019). Tests at school have points, and class rank functions as a sort of leaderboard, but people don’t consider these as gamified contexts, and rightfully so; there is something intrinsic about a game that is more than just its easily quantified measures. Additionally, a number of studies lack the proper controls that are required to truly examine the causal effects of a gamified condition, which makes it hard to draw conclusions from some findings (Fitz-Walter, Tjondronegoro, & Wyeth, 2011; Cheong, Cheong, & Filippou, 2013).

This proposed study aims to combat some of these common drawbacks while learning more about the specific elements of a game that can motivate learning. Positive reinforcement plays a well-established role in motivating students’ academic behavior (Diedrich, 2010). The present study is focused on positive reinforcement in two forms: traditional, verbal reinforcement, and reinforcement through gameplay consequences. I am curious how these constructs, embedded in a gamified environment, affect learning. I hypothesize that both of these constructs will influence learning positively in an additive manner, such that the participants in the condition that experiences both types of positive reinforcement will have the greatest learning outcomes, measured by their test scores at the end of the study.

**Methodology**

Study Design

All educational game variations were developed by modifying a traditional Pokémon FireRed 1.0 Game Boy Advance ROM. Modifications to this ROM were made using HexManiacAdvance, a free hex-editing tool built specifically for modifying Pokémon games.

Two significant changes are ingrained into the original story and gameplay of Pokémon. Firstly, there are eight different sections of the game where the screen blacks out and a narrator reads a short paragraph about climate change, which is displayed on the player’s screen. The player receives a notebook which can be used to recall this information at any time after its initial narration. When the player receives this notebook, they are informed that an understanding of the periodically narrated information is essential for their success throughout the game and are recommended to frequently review the information in their notebook, particularly before an upcoming gym leader. The eight gym leaders are the second significant modification. Each is paired with a narration blurb that covers a specific climate change topic. Before a player battles a gym leader in the traditional manner, they are asked three multiple choice questions. The player does not receive the narration directly before encountering a gym leader. Therefore, the intended path is for the player to receive the narration, continue playing the game until encountering the gym leader, and then review their notebook before starting the challenge. The result of answering these questions correctly or incorrectly varies on experimental condition. However, in every condition the player is informed whether they were correct or incorrect, and if they were incorrect, they are informed of the correct answer.

The three multiple choice questions are structured to work their way up Bloom’s Taxonomy, such that the first question is generally simple recollection and the third requires more critical thinking (Krathwohl, 2002). Consider these two examples from the first gym leader, where the correct answer is bolded:

Question 1

Which of the following is NOT a greenhouse gas?

a) Carbon Dioxide

**b) Nitrogen**

c) Methane

d) None of the above, these are all greenhouse gases

Question 3

What do you think is the main reason that global warming has become an increasingly important issue for scientists over the last century?

a) The increasing number of volcanic eruptions has radically changed the climate

b) Fluctuations in solar radiation have further degraded the ozone layer

c) Tectonic shifts have caused underground greenhouse gases to leak into our atmosphere

**d) Human activity since the Industrial Revolution has dramatically changed the amount of greenhouse gases in the atmosphere**

While question one simply requires the player to recall that carbon dioxide and methane were previously identified as greenhouse gases, question three presents them with four legitimate causes of global warming, and they are tasked to identify which of these four causes is most significant for climate scientists.

The operationalizations of the positive reinforcement constructs move parallel with this ascending up Bloom’s taxonomy. Verbal positive reinforcement following the first correct question simply congratulates the player and tells them “well done!” However, following the third correct question, the player receives specific praise acknowledging that they have been paying attention, learning, and have now mastered the topic, which tends to lead to optimal results when attempting to reinforce academic behavior (Diedrich et al., 2010).

In the gameplay consequence condition, when the player enters a challenge with a gym leader they are put at a disadvantage. The gym leader’s team of Pokémon has their stats raised, and the challenge occurs in an environment that benefits the gym leader’s Pokémon, making them faster and stronger. As the player answers the first two questions correctly, these advantages are nullified. Finally, a correct answer to the third question results in the player being put at an advantage, giving their team a stat boost. The player is not expected to understand the mechanics of the game, as they are explicitly informed through simple language after each correct answer that they have either lessened their disadvantage or gained an advantage. Additionally, they would further experience the effects of their correct answers, as the gym leader challenge will be noticeably easier.

Four conditions are constructed using various combinations of these constructs. One condition will have both constructs, such that the player’s correct answer to a question results in positive verbal and gameplay reinforcement. Two conditions will have one construct, such that the player receives either positive verbal reinforcement or positive gameplay reinforcement. Finally, the fourth condition acts as a control, and has neither of the constructs; the player is only informed of their correctness, accompanied with the correct answer if they answered incorrectly.

After the participants have completed playing the game, they would take a test covering the information from the eight climate change topics. The scores on these tests are the primary dependent measure that is used to track the efficacy of their condition in teaching them about climate change. Participants would also complete general demographic information, including race, gender, age, and educational level.

The main data analysis performed would be examining the main effects of the two different positive reinforcement constructs on the dependent variable of test scores following the game. Additional data analyses could be included, such as looking at the relationship between the number of times a player opened their notebook and their test scores, or an interaction effect between the two different constructs. Lastly, demographics would be examined to determine any potential relationships with construct efficacy.

Demographics

The ideal sample for the proposed study is elementary and middle school students, specifically 5th-8th grade. There is a chance that high school and college students may exhibit a ceiling effect, such that they would know most of the climate change information attempting to be taught to them throughout the game. However, students below 5th grade likely do not have the reading comprehension or critical thinking to understand all of the narration and subsequent questions. Additionally, students in this age range commonly struggle in traditional educational contexts, such as reading a textbook or sitting in a classroom, so more research on alternative educational methods may be helpful for this target population. There is precedent of gamification being effective in education (Mayer, 2019)—including specifically science education (Barab et al., 2009)—and among elementary school students (Alshammari, 2020).

Ethics

There is very little risk associated with this proposed study design. However, there are still some considerations. The consequences of climate change include natural disasters, severe weather, and other adverse outcomes that significantly impact people’s lives. A content warning may be necessary to inform participants that these consequences will be discussed, which may be a sensitive topic for some people. Additionally, since the target population consists of minors, parental consent would be necessary. The unmodified ROM is intended for children and consistently gets maturity ratings consistent with the target population. No personally identifying information will be collected, and participants will not be linked to their test scores or game performance in any way. All participants and their parents will be fully debriefed on the objective of the study. All data will be housed on secure, password-protected, University of Richmond computers.

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