Gamification in the classroom: How different types of leaderboards and levels of goal-setting affect performance and motivation in a problem solving task

Word Count: 4,314

Introduction

Gamification is becoming a staple in education. From Kahoot! to class rank, leaderboards are used to increase the motivation of students. A study by Fotaris et al. (2016) found that gamification using leaderboards does in fact increase student motivation. One classroom tool that Fotaris et al. investigated was Kahoot! Kahoot! was shown to increase student engagement in the classroom, which in turn benefitted motivation. However, "as the semester progressed though, it was noticed that the students' engagement decreased slowly in the Kahoot! sessions" (Fotaris et al., 2016, p. 107). This was speculated to be because "students competing at the individual level in Kahoot! began to lose interest once they trailed behind in the leaderboard" (Fotaris et al, 2016, p. 107). Conversely, according to a study by Brandstätter et al. (2019), "when a goal is appraised as relatively more ambivalent, proximity (vs. distance) to the goal might have a negative effect on net motivation" (p. 778). This is interesting because it indicates that "approaching a goal might undermine optimal performance in the late stages of personal goal pursuit" (Brandstätter et al., 2019, p. 791). This also suggests that top performers in Kahoot! games may succumb to pressure and decrease their performance because they are fully aware of their scores and how they compare throughout the game.

The other game which Fotaris et al. explored was an educational game of Who Wants to be a Millionaire (WWTBAM). In contrast to Kahoot!, WWTBAM required students to "compare and discuss their answers with their teammates in order to come to a consensus regarding the answer" (Fotaris et al., 2016, p. 107). This helped students to improve "their communication efficiency and [hone] important employability skills such as problem solving, critical thinking, and collaboration" (Fotaris et al., 2016, p. 107). As a result, "the engagement for WWTBAM remained unchanged," unlike in Kahoot! (Fotaris et al., 2016, p. 107). Interestingly, the findings

in Fotaris et al.'s study explain the results in Sancho-Vinuesa's study. After testing teaching tools with automatic feedback, results suggested that the provision of immediate feedback in an online mathematics course "significantly reduced the number of students who dropped out and improved academic results" (Sancho-Vinuesa et al., 2013, p. 51). However, it was unclear whether a discovered boost in self-efficacy was due to "the immediacy of the feedback [and/or] the information given as feedback following validation of the answer" (Sancho-Vinuesa et al., 2013, p. 65). Fortunately, the results of Fotaris et al.'s study support the notion that immediate feedback, such as in Kahoot!, increases student engagement and self-efficacy, or confidence to achieve a goal, and thus performance. However, a study by Shute and Emihovich (2018), which investigated strategies in gamification, implied that simple tools, like Kahoot!, which only offered multiple choice questions, do not prepare students for the real world where varied skills and problem solving are essential.

Despite the widespread use of leaderboards in education, few, if any, sources in the current literature acknowledge the existence of different types of leaderboards. This is clearly a gap in the field. The leaderboard used in Kahoot! can be classified as a fully live leaderboard. Students compete against fellow classmates to answer multiple-choice questions. The scores and names of each player are displayed between each question, giving players instant feedback. Class rank, on the other hand, can be classified as a semi-live leaderboard. Students are aware of their own class rank and GPA, but not those of their classmates. This means that while students know how they compare to their fellow classmates, they do not know the magnitude of their scores compared to those around them. Following this progression, another type of leaderboard may exist. A hidden live leaderboard would be a leaderboard where players do not know their own rank or the ranks and scores of their peers until the very end of the competition. The leaderboard

would be invisible. The effects of all three of these types of leaderboards will be investigated in my study.

Literature Review

It is well-known that leaderboards positively influence motivation and performance in individuals. This is largely due to the encouragement of goal-setting. In "Gamification of task performance with leaderboards: A goal setting experiment," Landers et al. (2015) explored how leaderboards affect the goal-setting tendencies of participants. The results of the study suggest that "leaderboards are approximately as effective as difficult-to-impossible goals to increase task performance" (Landers et al., 2015, p. 6). This means that participants exerted more effort as a result of setting higher standards. Thus, they achieved better performance. Alternatively, "if people do not believe a leaderboard provides worthwhile goals, leaderboards will not be successful at altering employee behavior" (Landers et al., 2015, p. 6). Therefore, the presence of leaderboards alone may not improve performance. However, rewards to go along with leaderboards are often used to incentivize participants and create meaning in the gamified task. Gamified tasks also benefit motivation and performance by encouraging strong Need for Cognitive Closure (NFC). According to a study by Szumowska et al. (2018), "NFC was related to a more mono-tasking strategy in the mono-tasking condition (Studies 1 and 2 only) and more dual-tasking strategy in the dual-tasking condition (Studies 1–3). This translated into respective differences in performance" (p. 360) Interestingly, reflecting the research of Landers et al. (2015), "the effects were significant only when goal importance was high (Study 1) and held when cognitive ability was controlled for (Study 2)" (Szumowska et al., 2018, p. 360). According to both Szumowska et al. and Landers et al., some sort of reward is required for leaderboards to be effective.

Rewards are often provided to entice players to perform to certain standards. The idea of rewards from the goal-setting aspect of leaderboards is explored in Tzur et al. (2016). In this study, they tested how rewards affect self-efficacy, and in turn, how rewards can affect motivation in certain situations. The results of this study clarify a discrepancy in the field, confirming that "the self-efficacy effect tends to be positive when reward is high and negative when reward is low" (Tzur et al., 2016, p. 373). Furthermore, "depending on reward, the negative effect of self efficacy on performance is not unique to within-person designs and the positive effect of self-efficacy on performance is not unique to between-person designs" (Tzur et al., 2016, p. 373). Of course, as noted in Landers et al.'s (2015) study, because participants automatically set high goals for themselves under leaderboard scenarios, intrinsic motivation is high.

Leaderboards themselves may offer intrinsic rewards to motivate individuals. In their study, Sailer et al. (2017) investigated how different elements of gamification affect psychological need satisfaction, which is important for participants to find the motivation to complete and put effort into objectives. The results of this study suggest that "badges, leaderboards, and performance graphs also seemed to contribute to an increase in perceived task meaningfulness" (Sailer et al., 2017, p. 378). Perceived task meaningfulness is a vital component of effective leaderboards. Again, the notion that purpose is required in gamified tasks is supported by Landers et al. (2015). Additionally, Fotaris et al. (2016) noted in their study that competition, a form of "intrinsic motivation, is driven by an interest or enjoyment in the task itself and inspires people to initiate an activity for its own sake" (p. 6). Furthermore, "students who are intrinsically motivated are more likely to engage in a task willingly, as well as work to improve their skills, which will increase their capabilities" (Fotaris et al., 2016, p. 6). Thus,

increasing the intrinsic incentive of gamified tasks can help motivate students. In fact, one feature of Kahoot! does just this. According to an evaluation of Kahoot!, "when learners start playing, they need to enter a nickname, which allows students to stay anonymous, and their recorded scores are saved in their profile. This unique feature makes Kahoot an engaging platform" (Cutri et al., 2016, p. 1). The results of this study are supported by Seo et al. Before conducting their research, they noted that "in spite of the motivational benefits, students often fail to accomplish self-set goals because they lack the social motivator ascribed to assigned goals" (Seo et al., 2017, p. 386). The results of their study supported the general consensus in the gamification field: "when autonomous goals (in this case, self-chosen goals) are coupled with implementation intentions, they facilitate goal progress" (Seo et al., 2017, p. 398). Furthermore, "without implementation intentions, despite all their benefits for psychological functioning, self-set goals may not effectively yield successful goal pursuit and performance" (Seo et al., 2017, p. 398).

Overall, while intrinsic motivation is important for gamification, certain tools and strategies, such as tangible reward, clear purpose, and leaderboards help bring out motivation and increase effectiveness. Thus, I will investigate how different types of leaderboards and levels of goal setting affect student performance and motivation in a problem solving task in order to better understand the gamification tools that are currently being used in the classroom.

Method

In order to investigate how different gamification elements like leaderboard types of goal levels affected performance and motivation in a problem solving task, a slide puzzle video game where participants will play a slide puzzle game while competing against other participants was programmed. The use of a computer program allows test conditions to be easily changed for each

sample group while also collecting large amounts of quantitative data relating to performance. Correlational statistics will be used in this study in order to investigate any possible relationships between the collected quantitative data. This data, including points, rank, performance over time, and survey responses, will be collected from participants while they play a competitive slide puzzle video game. Correlational statistics are appropriate in this study because they can find initial relationships that will grant insight into the topic of inquiry as well as guide future, more elaborate research.

Population

The video game puzzle task will be distributed to high school students in math classes. Obviously, high school students will be used in this experiment because the population of interest contains students who will experience educational gamification in school. The population will be divided into test groups based on their class period. This will allow for students to compete against their fellow classmates in a similar physical environment. While the academic level of each test group may vary, the use of different types of students is justified in existing literature. Chapman and Rich (2018) found that "being a member of any measured demographic (e.g., gender, age, student status) was not a barrier to finding gamification motivating" (p. 315). Therefore, all types of students, regardless of academic level, will find gamification motivating.

Video game task

In order to collect quantitative data relating to the performance and importantly to the motivation of students as they complete a problem solving task, the gamified task in this study consists of a slide puzzle game. In a slide puzzle game, players must rearrange numbered tiles in numerical order in order to gain points. A picture of the slide puzzle video game is displayed in

Figure 1. Each time players solve the puzzle, the board will be reshuffled and a point will be gained. The game will end after 20 minutes. However, there is an "End Game" button included on screen if students decide that they are uncomfortable playing the game midway through the task. A results screen will appear following the game that shows the winners to all players, as shown in Figure 4. A survey will follow this results screen. Statistics can be easily gathered throughout the duration of the task because it is programmed.

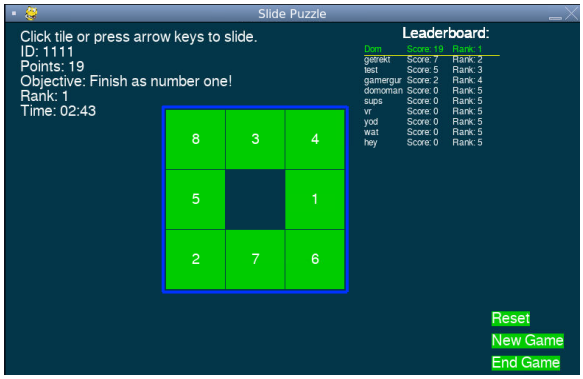

Figure 1 Slide puzzle video game task with fully-live leaderboard

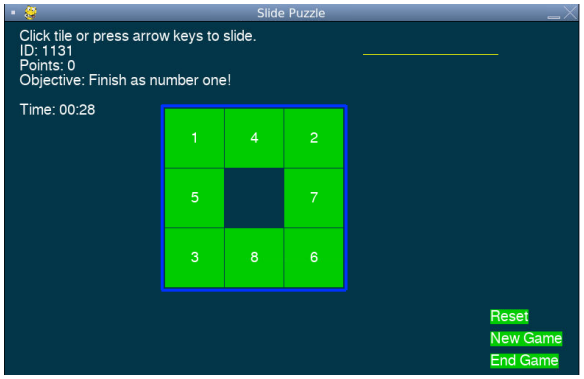

Figure 3 Slide puzzle video game task with hidden-live leaderboard; players can only see their own scores.

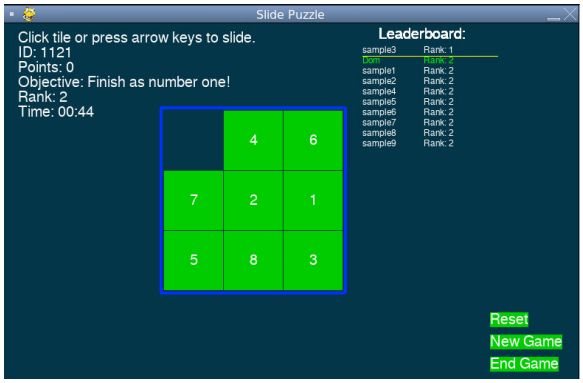

Figure 2 Slide puzzle video game task with semi-live leaderboard; players can see their own score and rank as well as the ranks of all other players, but they cannot see other player's scores.

Figure 4 Results screen depicting the winner of a game where the goal was to finish as number one

Variables

I will test the following three types of leaderboards:

- Fully-live leaderboard (shown in Figure 1):
    - Players can view their own score and rank as well as the ranks and scores of all other players.
    - A leaderboard will appear on screen showing the ranks and scores of all players.
        - A yellow line will appear on this leaderboard that indicates the cutoff of the goal in the test group.
        - The player's name will be highlighted in green on the leaderboard so that the player can more easily locate their own name.
- Semi-live (shown in Figure 2):
    - Players can only view their own score and rank.
    - No leaderboard will appear on screen showing the ranks and scores of all players.
- Hidden-live (shown in Figure 3)
    - Players can only view their own score.
    - No leaderboard will appear on screen showing the ranks and scores of all players.

I will also be testing fives levels of goal-setting:

- Top 100%:
    - All players will be shown on the results screen.
- Top 50%:
    - Only the top 50% of players will be shown on the results screen.
- Top 25%:
    - Only the top 25% of players will be shown on the results screen.

- Top 10%:
    - Only the top 10% of players will be shown on the results screen.
- Top 1:
    - Only the first place player will be shown on the results screen.

Measurements

Multiple measurements relating to the performance of players will be recorded throughout the duration of the task. These statistics are important because they form the quantitative backbone to my research inquiry of investigating the relationship between gamification elements and performance. These data will be derived solely from the player performance data, which does not include survey responses.

- Points:
    - The number of points that each player ends the task with.
- Rank:
    - The final rank of each player at the end of the task.
    - Rank can be converted into a percentile by dividing by the size of the group.
- Motivation:
    - The slope of the line of best fit of a plot of how long it takes for a player to gain a point on the y-axis versus total points on the x-axis will generate a quantitative value for motivation.
    - MATLAB was used to generate the graph and line of best fit (depicted in Figure 5).

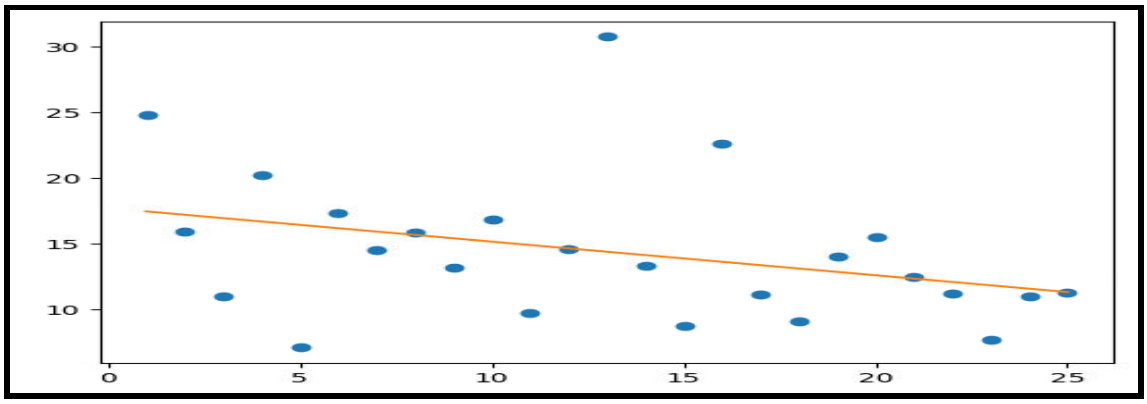

Figure 5 MATLAB plot of time per point (y-axis) versus total points (x-axis) with the line of best fit

Post-Game Survey

Following completion of the video game task, players will complete a survey. This survey is quantitative, containing several Likert-type questions on a scale ranging from one to five. The following questions will be asked in the post-game survey:

- "How motivated were you to complete the assessment?"
    - This question ranges from not motivated (1) to very motivated (5).
    - This question gauges whether a player was generally motivated or unmotivated during the task.
- "Did the presence of a leaderboard cause you to gain or lose motivation to achieve your assigned goal?"
    - This question ranges from highly lost motivation (1) to high gained motivation (5).
    - This question gauges whether players felt that the leaderboard was responsible for motivating or demotivating players.
- "How confident were you that you could reach your assigned goal near the end of the task?"
    - This question ranges from not all confident (1) to highly confident (5).

    - This question gauges whether a player was generally confident in their ability to achieve their goal.
- "Did the presence of a leaderboard cause you to gain or lose confidence that you could achieve your assigned goal?"
    - This question ranges from highly lost confidence (1) to highly gained confidence (5).
    - This question gauges whether players felt that the leaderboard was responsible for increasing or decreasing their confidence in their ability to achieve their goal.
- "How difficult did you find the puzzle to be?"
    - This question ranges from very difficult (1) to very easy (5).
    - This question gauges how challenging a player found the slize puzzle to be, and it may be important in order to account for misattributions of poor performance that were due to difficulty with the particular puzzle rather than low motivation.
- "How enjoyable did you find the puzzle to be?"
    - This question ranges from very unenjoyable (1) to very enjoyable (5).
    - This question gauges how much fun players had while playing the slide puzzle game, which may be a possible explanation for high performance in players

Hypotheses

Based on the current literature, the following outcomes are hypothesized:

1. Suspenseful leaderboards, or leaderboards that hide more information from players until the end of the task, will increase the average performance and motivation of all players.
2. Lenient goals, or goals that are more easily achieved by players, will increase the average performance and motivation of all players.

3. Self-reported player motivation can be accurately predicted by using player performance over time.

Results

Among the 15 test groups, there were 62 total participants whose data could be analyzed. As shown in Figure 6, there was positive correlation between score and leniency of goal. The R-squared value of the line of best fit for this graph was 0.748, which indicated a high level of correlation. Similarly, as shown in Figure 7, there was also a positive correlation between score and suspensefulness of leaderboard. Because the R-squared value was 0.871, there was a high level of correlation. While score was clearly related to the assigned goal and leaderboard type, there were no significant relationships between self-reported motivation and these gamification elements. The scatterplot of self-reported motivation versus assigned goal yielded an R-squared value of 0.011 while the scatterplot of self-reported motivation versus leaderboard type yielded an R-squared value of 0.429. Both graphs (depicted in Figure 8 and Figure 9) had lines of best fit that were nearly horizontal, indicating that the average self-reported motivations among each type of leaderboard or level of goal were nearly equal. With regards to the motivation value that was calculated using player performance over time throughout the duration of the task, an R-squared value of 0.533 (depicted in Figure 10) suggested that the motivation coefficient was moderately correlated with self-reported motivation.

With an R-squared value of 0.938, the percentile that players finished the game in was predictably strongly correlated with how difficult they found the task to be (depicted in Figure 11). However, self-reported difficulty was not correlated with self-reported motivation (depicted in Figure 12). Interestingly, the strongest predictor of self-reported motivation was self-reported fun with an R-squared value of 0.975 (depicted in Figure 13).

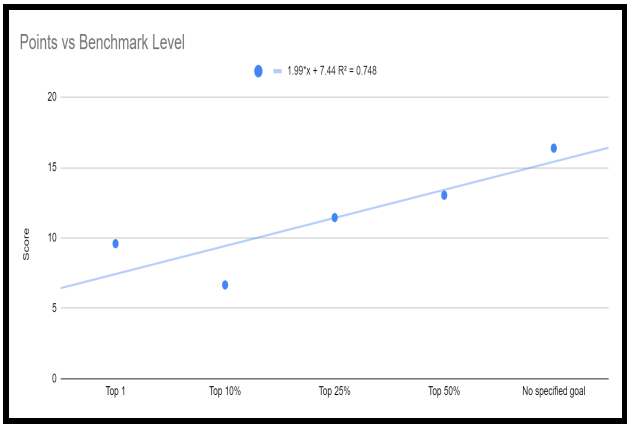

Figure 6 Average score versus assigned goal to achieve.

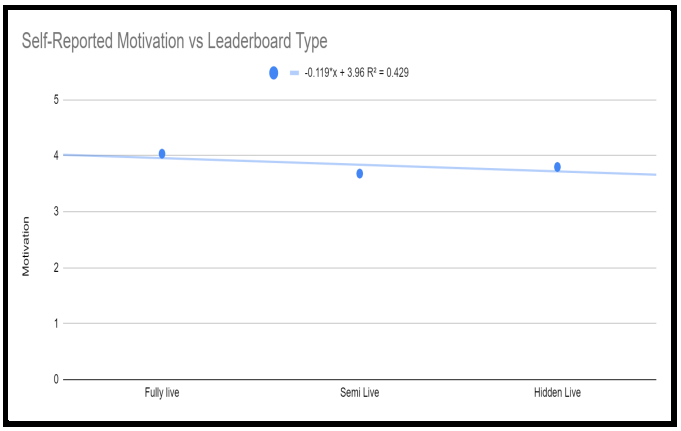

Figure 9 Self-reported motivation versus leaderboard type.

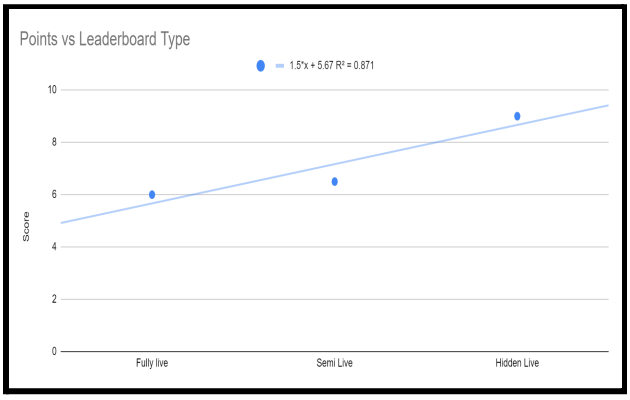

Figure 7 Average score versus leaderboard type.

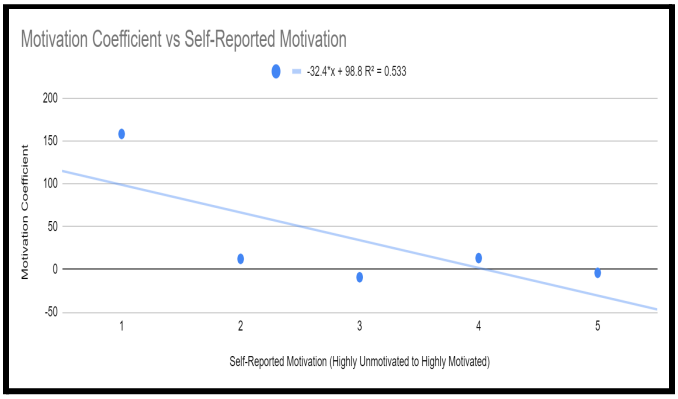

Figure 10 Calculated motivation value versus self-reported motivation from the survey.

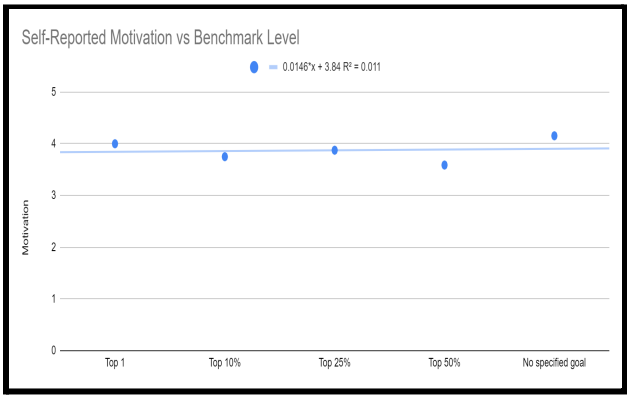

Figure 8 Self-reported motivation versus assigned goal to achieve.

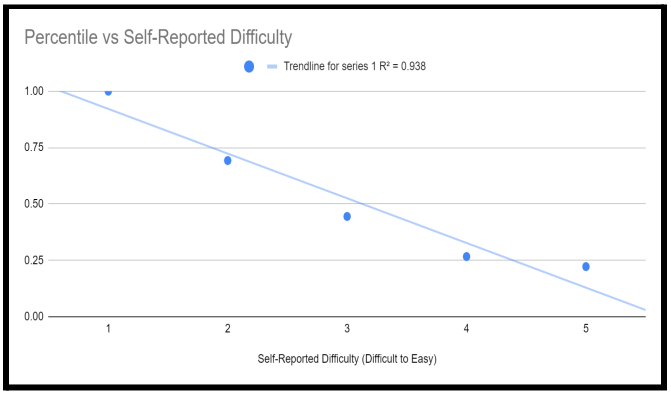

Figure 11 Percentile (Rank/Group Size) versus self-reported difficulty.

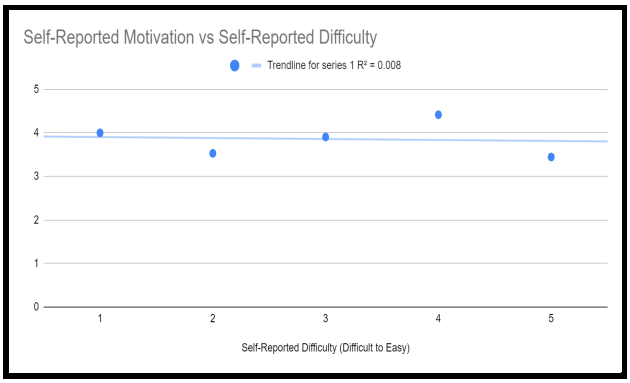

Figure 12 Self-reported motivation versus self-reported difficulty.

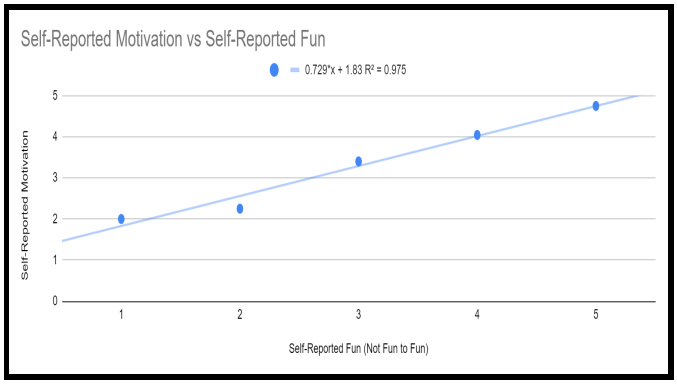

Figure 13 Self-reported fun versus self-reported difficult.

Discussion of Results

The hypothesis that, on average, players performed better under conditions with less strict goal levels was correct. This could be explained by players giving up when they realized that they were unable to reach the goal during the task under stricter conditions. Alternatively, the hypothesis that, on average, players with less visible leaderboards would perform better was correct. Under less visible, and thus more suspenseful, leaderboards, players would be unaware of how far away they are from reaching the assigned goal, and thus they not give up near the end of the trial. However, there was no correlation between the motivation of players and the different goal levels or the different leaderboard types. This was evident because the R-squared value of each graph indicated no correlation. This finding is surprising because average performance clearly suffered under certain goals or leaderboard types. This discrepancy between performance and motivation can also be found in the motivation value that was calculated using only player performance. The relationship between predicted and self-reported motivation yielded an R-squared value of 0.533, indicating only a moderate correlation. Self-reported difficulty with the puzzle task also did not show any significant correlation with self-reported motivation. Interestingly, there was one extremely accurate predictor of self-reported motivation:

self-reported fun. This discovery makes sense because players who enjoy the task will obviously be more intrinsically motivated and rewarded by playing the game.

Limitations

There were a few notable limitations that may have impacted the results of this study. One limitation was that sample sizes were much smaller than anticipated. Originally, three trials were going to be conducted under each combination of goal level and leaderboard type, totaling 45 total trials. Furthermore, each group had enough space to accommodate for 30 participants. However, only 15 trials with an average of 4 players per trial were able to be completed. Not only could this low number of participants resulted in less accurate data, but it also may have diminished certain goals. For example, in a group of 4 people, there is no difference between the number of winning players in trials where the goal is to achieve top 1, top 10%, or top 25%.

Another major limitation was that players may have struggled due to unfamiliarity with the puzzle game rather than due to unmotivation. Although players were shown a video explaining how to navigate the interface of the game and the objective of the game prior to the task, players may have still been confused about how to play the game. Furthermore, they may have discovered new and improved strategies over the course of the game, meaning that any increases in performance that accounted for in the calculated motivation coefficient may have actually been due to improved strategies that would have increased the rate of attaining points regardless of motivation.

Finally, variance in performance between test groups may have been affected by the way that groups were chosen. Students completed the video game puzzle task during a math class, meaning that sample groups consisted of one math class each. As a result, advanced math classes may have naturally achieved higher scores on average, regardless of test conditions, which may

have skewed the results. Replication of this experiment may wish to have all participants complete the task at the same time, assigning random test groups to each participant.

Suggestions for Future Research

Future research building upon this study should seek to replicate this experiment with larger sample sizes in order to validate the accuracy of the data in this study. Alternatively, in order to boost the accuracy of the calculated motivation coefficient, players should be better familiarized and fairly comfortable with the game prior to the task in order to ensure that fluctuations in performance over time are due solely to fluctuating motivation. Otherwise, increases in performance due to students discovering more efficient strategies in the game will be confused with an increase in performance due to motivation. Additionally, this research offers a solid first step into exploring the effectiveness and applicabilities of the different types of leaderboards, seeking to fill this gap. Future research should follow up on this idea, either by repeating this experiment with larger, better randomized samples, by testing the different types of leaderboards covered in this study when combined with other conditions not explored in this study, or even by trying out new types of leaderboards not considered in this study.

Conclusion

According to the results of this study, while more suspenseful leaderboards and more lenient goals increased the average performance of players of a slide puzzle video game, their motivation was unaffected. Alternatively, motivation could only somewhat accurately be predicted based on player performance over time. Interestingly, the strongest predictor of motivation was actually fun.

These findings have numerous implications in the real world. For example, in education, school administrators seeking to increase performance, such as grades or test scores, should

consider implementing more suspenseful versions of class rank where students do not know their rank until their final high school transcripts come out, or they should consider applying more lenient goals to achieve, such as rewarding the top 10% in a class based on class rank at the end of high school. However, applying these improvements to currently utilized gamification elements may be risky because while an increase in performance was found, an increase in motivation was not. Therefore, students may experience more stress by having to perform to a higher standard with an increase in motivation. Regardless, because fun was clearly the best predictor of motivation, educators or educational faculty should seek to create a classroom environment that is as fun and engaging as possible in order to motivate students. Obviously, students who are more interested in class material will be more willing and more intrinsically motivated to exert the effort necessary to complete academic assignments.

My findings also have several implications in the research field. First, this research does address a notable gap in the field. Prior to this study, no other research has been conducted that has explored the different types of leaderboards, much less how different levels of goal setting affect each leaderboard type. Additionally, calculation of motivation using solely player performance data appears to be promising. Improvements upon this calculation may allow researchers to more subtly and perhaps more accurately measure or assess motivation in video game based situations than by using survey responses. On the other hand, the finding that more suspenseful leaderboards increased the average performance of players was expected based on Fotaris et al.'s (2016) explanation that "students competing at individual level in Kahoot! began to lose interest once they trailed behind in the leaderboard" (p. 107). Furthermore, this study also clarifies a discrepancy in Sancho-Vinuesa et al.'s (2013) study. The results of their study suggested that the provision of immediate feedback in an online mathematics course

"significantly reduced the number of students who dropped out and improved academic results" (Sancho-Vinuesa et al., 2013, p. 51). However, it was unclear whether a discovered boost in self-efficacy was due to "the immediacy of the feedback [and/or] the information given as feedback following validation of the answer" (Sancho-Vinuesa et al., 2013, p. 65). The results gathered in my study suggest that the information given as feedback offered the discovered boost in self-efficacy because subjects in my study did not receive any motivational boosts as a result of the immediate feedback of a leaderboard.

In conclusion, while more suspenseful leaderboards and more lenient goals may increase the average performance of all students involved in a competitive problem solving task, these gamification elements will not necessarily increase their motivation. In order to accomplish this feat, educators must make learning as fun and engaging as possible for students. Gamification will inevitably become an even bigger part of the classroom as technology is further implemented into the curriculum, so educators should embrace it and use it to its fullest potential.

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