Evaluating the Impact of Serious Games on Study Skills and Habits

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Abstract: Learning is a constructive process that requires dedication and motivation. Learning games can be used to engage learners, by providing opportunities to apply knowledge in a safe and fun environment. We created a peer-quizzing game that allows students to quiz each other on the course material and to playfully engage in good study habits. We set out to explore if learners with better learning skills and habits would be more engaged in the game in the context of a first-year computer science university class. We used the "Study Skills and Habits Questionnaire" to study the relationship between study skills and habits (especially time management, concentration, goal setting, and comprehension) and engagement in a competitive version of a peer-quizzing game including a leaderboard. We collected and analysed gameplay data of the students (n=34), such as creating quiz questions and solving the questions created by their peers. The results of the data analysis showed a moderate positive correlation between study skills and habits (time management, concentration, goal setting, and comprehension) and the number of questions answered and a moderate negative correlation with the number of questions created in the game. However, the regression model was not statistically significant in explaining the variation in the dependent variable (questions created). Among the individual predictor variables, only goal setting had a statistically significant positive effect on the number of questions created. Other variables, such as time management, concentration, and comprehension, did not show significant effects on the number of questions created by students.

Keywords: Serious games, Peer-quizzing, Engagement

1. Introduction

The recent popularity of game-based learning and serious games has influenced researchers to experiment with various approaches. Researchers using game-based learning tools and serious games have mostly reported having a positive impact from their implementations (Anastasiadis et al., 2018; Arif et al., 2022; Landers et al., 2017; Lin et al., 2017). Learners enjoy game-based learning and serious games because of the extra layer of entertainment and excitement added by interacting competitively with their peers in an environment constrained by the game mechanics and dynamics related to a learning task. Some common game elements are points, badges, and leaderboards. Using these game elements, the hardship of the main task becomes less noticeable because of the rewards and satisfaction. Researchers have explored various game elements, and the design process of game-based solutions and serious games welcomes exploration and creativity (Arnab et al., 2015; Chou, 2015; Nah et al., 2013; Wang et al., 2016).

Learning is a natural process that takes place both inside and outside the classroom. We learn various things both voluntarily and involuntarily. Sometimes we learn things by experience, and sometimes by hearing others' experiences. Either way, learning is fun as long as the learners are motivated (Bergin & Reilly, 2005). Game-based learning is an innovative approach to teaching that uses games to deliver educational content. The method has been shown to increase student engagement and motivation (Sailer et al., 2017) and to improve learning outcomes. Serious games, on the other hand, are games designed with a primary purpose other than learner motivation. Serious games are created with the intention of passing knowledge, developing specific skills by practicing them in a simulated environment, or changing behaviours in a targeted audience.

Both game-based learning systems and serious games often include leaderboards, which are used to track and display players' performance. Leaderboards can be a powerful motivator for students, as they provide a way to compare their performance with that of their peers (Huang & Hew, 2015). However, leaderboards are not equally motivating for learners. While they may be very motivating for competitive students, they may be demotivating for others (Toda et al., 2018; Wells & Skowronski, 2012). It is likely that personality type, the student's mindset, self-efficacy, and study skills and habits play a role in the motivational effect of games on students.

Survey tools are widely used to identify individual features of learners. The "Study Skills and Habits Questionnaire" (SSHQ) is a standardized assessment tool to measure an individual's study habits and skills (Nourian et al., 2008). It is designed to assess a range of study-related behaviours and attitudes important for academic success, such as time management, note-taking, concentration, and motivation (Nourian et al., 2006). The questionnaire typically consists of a series of statements or questions that the individual answers using a

Likert scale, which measures the degree to which they agree or disagree with each statement. The responses are then scored and analysed to provide insights into the individual's study habits and skills. Educators and academic researchers often use the Study Skills and Habits Questionnaire to evaluate the effectiveness of different teaching methods, study programs, and interventions to improve student study skills and habits.

We aim to explore if study skills and habits play any role or show any associations with gameplay behaviours in an educational game. We designed a study in which we measured the study skills and habits of students before playing a competitive learning game during one semester of a first-year university programming course. We focus on a competitive game, because competition is an important factor that contributes to enjoyment and facilitate social activities (Vorderer et al., 2003). Using the SSHQ, we analyzed the relationship between student study skills and habits and their gameplay behaviours. The findings will allow game designers to tailor educational games to individual students.

2. Related Literature

In recent years, research into learning games has grown significantly. In addition to enhancing engagement, participation, and academic success, learning games as a pedagogical tool can also be used in creating and developing other skills in, such as research skills (Bellotti et al., 2013), leadership skills (Sousa & Rocha, 2019), communication skills, creativity, and adaptability (Barr, 2018). Prior studies, however, have demonstrated that student individual characteristics need to be considered. Otherwise, students may initially show interest and engagement in the learning process but as time goes on, their interest wanes and their performance declines (Hwang et al., 2012). For this reason, researchers are exploring the potential for profiling learners (Omarali, 2016; Tzouveli et al., 2008). For example, Hwang et al. (2012) propose a personalized learning games approach based on learning styles' sequential/global dimension. An experiment using a role-playing game in an elementary school science course was conducted to evaluate the method. Results indicate that personalized educational computer game enhances learning motivation and improves student achievements. Troussas et al. (2020) proposed a mobile learning tool "Quiz Time!" evaluating and increasing students' understanding of the programming language C#. The tool offers a personalized group play suggestion for collaboration using a vectorial-based recommendation module and tailored support based on the learner's profile using a dynamic fuzzy logic-based advice generator. Bang et al. (2023) utilizes My Math Academy, an adaptive Personalized Mastery Learning System to determine the effect of personalization on student learning gains. The system provides personalized math materials and adaptive embedded evaluations based on students' abilities. The researchers discovered that My Math Academy users significantly improved their math skills compared to non-users.

A study conducted by Denden et al. (2018) introduces a novel framework for modelling learners' personalities within a learning environment based on their gaming behaviours instead of just traditional surveys. The framework comprises a Computer Architecture Game (CAG) and a Learning Analytics (LA) system. The experiment involved 34 undergraduate learners and 11 teachers from a Tunisian University. While playing the CAG, the participants' gaming behaviour traces were collected, and their personalities were assessed using the Big Five Inventory (BFI) questionnaire. The results showed that the framework accurately modelled extraversion and openness personality dimensions and demonstrated moderate to good agreement compared to the BFI. The study suggested that this framework could advance learning games and educational psychology research by providing alternative methods for modelling learners' personalities without relying solely on questionnaires. However, the study had limitations, such as focusing only on the extraversion and openness dimensions, a small number of participants, and using only one algorithm (Naïve Bayes classifier) in the LA system.

Another study by Mekler et al. (2013) discussed the effects of implementing game elements, such as points, levels, and leaderboards, on user performance, intrinsic motivation, perceived autonomy and competence. In the study, participants were randomly assigned to one of four experimental conditions and asked to complete an image annotation task. The results suggested that implementing points, levels, and leaderboards may be an effective way to drive user behaviour in the short term and enhance performance in the task. However, the presence of these game elements did not increase intrinsic motivation. Therefore, designers of gamified services should be aware of potential social or contextual factors that may affect intrinsic motivation and not rely solely on game elements to sustain long-term user engagement.

Reyes et al. (2023) investigated a model predicting academic accomplishment. The findings demonstrated that learning strategies, study habits, and attitudes mediate the relationship between students' academic success and individual characteristics such as age, gender, and cognitive or behavioural involvement. Numan & Hasan (2017) conducted a study to determine the impact of study practices on undergrad students' test anxiety and

academic performance. They found that students who practise efficient study techniques score higher on academic tests and have lower levels of test anxiety. Furthermore, the research showed that girls outperform boys in the classroom and had better study habits. Additionally, the authors conducted a correlation analysis, revealing a strong positive association between study habits and academic success and a negative relationship between test anxiety, academic success, and study habits.

3. Experiment Design

This section presents our research methodology, how we recruited the participants, designed our experiment, and collected the data.

3.1 Recruitment of Participants

Our study was approved by the ethics board at the university with BEH ID-101. We recruited students from a first-year programming language course at our university. We used a pre-study survey to collect the students' demographic information, which also contained the "Study Skills and Habits Questionnaire" (SSHQ) questionnaire[1]. We used the SSHQ version from Queen's University's Learning Strategies and the Writing Centre[2]. The pre-study survey started with a consent form for participation. Participation was voluntary, and students who participated in our study received up to five percent of the final grade as participation marks in the class, depending on how actively they participated in the game. Students who opted out of the study had five percent weight added to their final exam.

Initially, 165 students signed up for the study. We randomly assigned the students into one of two groups, playing different versions of the game, one with leaderboards, and one without (just points). However, only 79 students played the game regularly. In this paper, discuss the results from the group with the leaderboard (n=34).

3.2 Peer-Quizzing Game

The participating students were assigned a pseudonym to play the quizzing game. The game is themed as a tower defence game where students create quiz questions based on the material from their course. They can create three types of quiz questions in the game: multiple-choice question (MCQ), true/false, and short answer. The students can create quiz questions, answer the questions created by their peers and view the solved questions. They receive points for creating and answering quiz questions correctly. In the game, asking a quiz question is synonymous with creating a tower, and answering a question is synonymous with attacking a tower. The game interface included two leaderboards, showing respectively the students who created and those who attacked the most towers. More information about the design of the game can be found in (Kiron et al., 2019).

3.3 Data Collection

Apart from the answers to the pre-and post-study survey questions, we collected each student's gameplay data. The gameplay data consists of the number of questions created and answered. In addition, we also collected a detailed log of all the events in the game, such as, the questions they created, answered, viewed, when they signed in and out with timestamps.

4. Data Analysis and Results

To study the relationship between students' study skills and habits and their engagement in the game multiple regression analysis was performed to examine the relationship between a dependent variable and multiple independent variables. In our case, we did two multiple regressions examining respectively the relationship between the number of questions answered (dependent variable 1) and the number questions created (dependent variable 2) and the students' time management, concentration, goal setting, and comprehension skills (independent variables). The goal is to identify the relationship between the variables and determine how much of the variance in the dependent variable can be explained by the independent variables. We also calculated the correlation coefficient between the four SSHQ items for study skills and habits and the numbers of questions created and answered. For analysis, we used the data analysis toolkit in Microsoft Excel. The results of the regression statistics, ANOVA, and regression analysis are presented in tables 1 to 3 below.

[1] https://www.scribd.com/document/535856383/Study-Skills-Habits-Questionnaire-2019 (At the time writing this manuscript, the original link was not operational. Therefore, we cited an alternative link containing the version we used for our study.)

[2] https://sass.queensu.ca/

4.1 Number of Questions Answered

As shown in Table 1, the multiple correlation coefficient (R) is 0.739. This indicates a moderate-to-strong positive correlation between the dependent (# of questions answered) and independent variables. The coefficient of determination (R squared) is 0.546. This means that 54.61% of the variation in the dependent variable is explained by the independent variables included in the model. The adjusted R squared is 0.212. This means that the independent variables in the model explain only 21.16% of the variation in the dependent variable after adjusting for the number of predictors in the model. The standard error of the estimate is 1.098. This represents the average distance the data points fall from the regression line.

Table 1: Regression Statistics for variables under the number questions answered.

Multiple R	0.738954
R Square	0.546053
Adjusted R Square	0.211566
Standard Error	1.098107
Observations	34

The ANOVA results in Table 2 show that the regression model is not significant at the 0.05 level of significance (p-value of 0.158). This means that the independent variables in the model do not significantly explain the variation in the dependent variable.

Table 2: Results from the ANOVA for variables under questions answered.

	df	SS	MS	F	Significance F
Regression	14	27.55963535	1.968545382	1.632510112	0.158264087
Residual	19	22.91095288	1.205839625		
Total	33	50.47058824			

The regression analysis in Table 3 provides the estimated coefficients for each independent variable. The intercept is 6.565. In a regression model, the intercept refers to the predicted value of the dependent variable when all independent variables are set at zero. It represents the average response that would be observed if all other factors were held constant and only one factor was varied. None of the independent variables are significant at the 0.05 level. Academic stress, with a p-value of 0.0731, though it is not less than 0.05, has a relatively lower p-value than the other variables, suggesting it could potentially be a significant predictor. Academic stress and attitude were not one of the items we were looking into for our present study, but we still included the items in table 3. A negative coefficient for an independent variable means a negative relationship between that variable and the dependent variable. For example, a one-unit increase in attitude is associated with a 1.257 decrease in the dependent variable.

Table 3: Results of the regression analysis for variables under questions answered.

	Coefficients	Standard Error	t Stat	P-value
Intercept	6.564505	2.917575233	2.249986524	0.036494338
Time management	-0.24144	0.586526951	-0.411636983	0.685211975
Concentration	-0.04986	0.363299588	-0.137239796	0.892285141
Goal setting	0.795159	0.776733698	1.023721844	0.318824939
Comprehension	0.234686	0.497424447	0.471802295	0.642440914
Attitude	-1.25702	0.70686428	-1.778308679	0.091360561
Academic stress	0.836127	0.440691843	1.897304381	0.073091995

4.2 Number of Questions Created

In Table 4 we can see that the multiple correlation coefficient between the second dependent variable, (# questions created) and the independent variables is close to 0.703. It indicates a moderate positive correlation.

The coefficient of determination is 0.494. It means that the predictors in the model explain approximately 49.4% of the variability in the questions created. The adjusted R-squared value is 0.121. It considers the number of predictors and the sample size to provide a more conservative estimate of the model's explanatory power. In this case, the adjusted R-squared is lower than the R-squared, suggesting that some predictors may not significantly contribute to the model's predictive ability. The standard error is 1.157. It represents the average deviation of the observed values from the regression line. Lower values indicate a better fit of the model to the data.

Table 4: Regression Statistics for variables under questions created.

Multiple R	0.702854712
R Square	0.494004747
Adjusted R Square	0.121166139
Standard Error	1.156647159
Observations	34

In Table 5, the regression analysis shows that the model with the predictors is not statistically significant (p = 0.279, and the F- statistic is higher than the critical value). However, the F-statistic of 1.325 suggests that the overall model's fit is not strong. The residual sum of squares (SS) is 25.419, indicating the unexplained variability in the data after accounting for the predictors. The total sum of squares (SS) is 50.2353, representing the total variability in the questions created.

Table 5: Results from the ANOVA for variables under questions created.

	df	SS	MS	F	Significance F
Regression	14	24.81647375	1.772605268	1.324982812	0.279349298
Residual	19	25.41882037	1.337832651		
Total	33	50.23529412			

Table 6 shows that the intercept term is 1.595 with a standard error of 3.073. The t-value of 0.519 suggests that the intercept is not statistically significant (p = 0.609). The coefficient for goal setting is 2.153. It suggests that for each unit increase in goal setting, there is an expected increase of 2.153 in questions created. The t-value of 2.631 and the p-value of 0.017 indicate that this effect is statistically significant. The rest of the independent variables do not yield statistically significant effects.

Table 6: Results of the regression analysis for variables under questions created.

	Coefficients	Standard Error	t Stat	P-value
Intercept	1.594860372	3.07311055	0.518972665	0.609772197
Time management	-0.844538358	0.617794578	-1.367021316	0.187576218
Concentration	0.345650813	0.382667012	0.903267859	0.377693646
Goal setting	2.152645786	0.818141206	2.631142118	0.016452696
Comprehension	0.065774261	0.523942039	0.125537284	0.901417033

In summary, the regression analysis indicates that the overall model is not strongly predictive of questions created, as evidenced by the low R-squared value and the non-significant F-statistic. Among the individual predictor variables, only the goal setting variable appears to have a statistically significant effect (p = 0.0165) on the outcome variable. This suggests that goal setting has a significant positive effect on the number of questions created. This finding implies that participants who have better goal-setting skills tend to create more questions.

In Table 6, the results presented a regression analysis, examining the relationship between variables under questions created. Each variable's coefficient, standard error, t-statistic, and p-value are provided. The p-value indicates the statistical significance of each variable in the regression model. A lower p-value suggests a stronger statistical significance. On the other hand, Table 7 displays the correlation coefficients between four items of the SSHQ and questions created, as well as questions answered. Correlation coefficients measure the strength and direction of the linear relationship between two variables.

From Table 7 we can see that there is a weak negative correlation between time management and questions created. This suggests that students with poor time management skills may have a slightly higher tendency to create more questions. Furthermore, a weak positive correlation exists between time management and questions answered. This implies that students with better time management skills may tend to attack questions slightly more.

Table 7: Correlation coefficient of four SSHQ items against questions created and answered

	Created	**Answered**
Time management	-0.05552	0.082009
Concentration	0.192323	0.163968
Goal setting	-0.24212	0.224018
Comprehension	-0.09412	-0.01572

A moderate positive correlation exists between concentration and both questions created and answered. This may imply that students with higher concentration levels are more likely to create and attack questions. When it comes to goal setting, there is a moderate negative correlation between goal setting and questions created. This may suggest that students with higher levels of goal setting may have a lower tendency to create questions. However, there is a moderate positive correlation between goal setting and questions answered. This may imply that students with better goal-setting skills may have a higher tendency to attack questions.

While comparing the p-values for the "Goal setting" variable in both tables, in Table 6, the p-value for "Goal setting" is 0.0164, which is below the conventional threshold of 0.05. This suggests a statistically significant relationship between "Goal setting" and questions created in the regression analysis. In Table 7, the correlation coefficients shown for "Goal setting" and questions created is -0.24212. However, correlation coefficients do not directly provide p-values. The p-value in Table 6 represents the significance of the "Goal setting" variable in the context of the regression model. In contrast, the correlation coefficient in Table 7 only indicates the strength and direction of the linear relationship between "Goal setting" and questions created.

The p-value in Table 6 demonstrates the statistical significance of the "Goal setting" variable within the regression analysis. In contrast, the correlation coefficient in Table 7 illustrates the strength and direction of the linear relationship between "Goal setting" and questions created. The different p-values between the two tables may arise from the nature of the statistical analyses and the specific data used in each calculation.

Regarding comprehension, there is a weak negative correlation between comprehension and questions created. This may suggest that students with lower levels of comprehension may be slightly more reluctant to create questions. Additionally, there is a very weak negative correlation between comprehension and questions answered.

5. Discussion and Limitations of the Study

Overall, there was only one significant relationship discovered in the analysis, between goal-setting and the number of questions created. One thing to note is that the Adjusted R-squared value in Tables 1 and 4 is substantially lower than the R-squared value, indicating that some of the variables in the model may not be contributing much. This suggests that the model may benefit from removing some of the less important variables and revising the selected variables may change the results. Additionally, some of the p-values for the coefficients are quite high, indicating that there is not enough evidence to reject the null hypothesis that the coefficient is zero. This suggests that these variables may not significantly impact the dependent variable. These results may be due to the fact that the participants group in this study was small. The general recommendation for linear regression models (including multiple regression) is to have 10-15 observations for each term. In our case this means 40-60 participants. Possibly more significant relationships could be found in a larger study

Overall, many versions of the Study Skills and Habits Questionnaire have been developed[3, 4] and validated by researchers in the field of educational psychology. These questionnaires typically undergo rigorous testing and validation to ensure that they measure the intended variables and produce consistent results over time. However, it's important to note that no assessment tool is 100% reliable, and factors can affect the validity of the results, such as individual differences in response styles or the influence of external factors like stress or anxiety. For our present study, we relied on the students' survey responses and the data we collected from the game. Therefore, it's essential to use the Study Skills and Habits Questionnaire in combination with other sources of information, such as interviews or direct observations, to obtain a complete picture of an individual's study skills and habits.

It is also important to remember that this is study is carried out in specific context (specific game and course) and we can't say for sure if these results apply to everyone. Many other factors, like coursework load, students' social life, and individual differences, can influence their behaviour in the game. Therefore, we need to study more to understand what makes some students more engaged in competitive learning games.

6. Conclusion

Serious games have become prominent in educational research that can aid in various learning outcomes. An enjoyable serious game influences students' motivation and interest in the game objectives or learning tasks. Learning abilities and habits are two additional factors that can also affect students' motivation to engage in learning tasks, which should be considered in the research on student engagement and academic success. To aid in this research, we investigated the effect of learners' study skills and habits on the student engagement in a peer-quizzing serious game.

The paper discusses using a serious game to engage students and improve their study skills and habits. We developed a learning game that allowed students to quiz each other on course material in a fun and interactive way. The study explored whether students with better learning skills and habits would be more engaged in the game. Therefore, we used the "Study Skills and Habits Questionnaire" (SSHQ) to assess various factors related to academic success, such as time management, concentration, goal setting, and comprehension.

We recruited thirty-four students to participate in the study. Gameplay data, including quiz creation and solving, were collected, and analyzed. We performed regression analyses and calculated correlation coefficients to examine the relationship between study skills and habits and engagement in the game.

The results showed a moderate positive correlation between study skills and habits (time management, concentration, goal setting, and comprehension) and the number of questions answered and a moderate negative correlation for questions created in the game. However, the regression model as a whole was not statistically significant in explaining the variation in the dependent variable (questions created). Among the individual predictor variables, only goal setting had a statistically significant positive effect on the number of questions created. Other variables, such as time management, concentration, and comprehension, did not show significant effects on the number of questions created by students.

The findings suggest that students with goal setting skills tend to engage in the game and create more questions. However, it is essential to note that the study has limitations: the sample size was small and the SSHQ survey covers only a limited set of personal variables. Further research is needed to understand the broader factors that influence engagement in serious games. Factors like course schedule, and individual differences, e.g., personality traits, can also impact students' engagement. While a valuable tool, the Study Skills and Habits Questionnaire should be used in conjunction with other sources of information to gain a comprehensive understanding of students' study skills and habits.

In conclusion, serious games can effectively engage students and improve their study skills and habits. In addition, the study found a positive correlation between goal-setting and engagement in the game, indicating that students with better goal-setting skills were more likely to participate actively. However, more research is needed to explore the broader factors that contribute to academic success and validate this study's findings.

[3] https://smgserv1.bu.edu/studyskills/

[4] https://www.uhcl.edu/counseling-services/resources/documents/handouts/study-skills-assessment-questionnaire.pdf

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