Engaging Students in a Peer-Quizzing Game to Encourage Active Learning and Building a Student-Generated Question Bank

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Abstract: Games are a great source of entertainment and are used by people of all ages; they motivate and engage people and affect their behavior. Therefore, games have been widely studied in many non-game contexts. Education is one of those areas where gamified, and game-based learning strategies have been implemented and explored. To engage and motivate students to quiz each other, and as a side effect, build a question bank, as well as to study the gaming and learning behavior of students, we used a peer-quizzing game called "Tower of Questions" (ToQ). The game uses some themes and mechanics found in tower defense (TD) games. The students received points for posing and answering the questions in the game in the form of gems. Students played the game with pseudonyms for one academic term and were told not to disclose their identities to anyone. We conducted a 3-month long study for two consecutive years in the same first-year undergraduate computer science course. In this paper, we present the findings from our studies using ToQ, specifically findings related to the students' self-monitoring and quizzing activities based on the game logs and two self-reported surveys from data collected in the second year of the study.

Keywords: gamification, game-based testing, peer-quizzing, incentives, engagement

1. Introduction

Computer games have become one of the favorite means of entertainment for people of all ages. Gamers spend countless hours trying to complete the challenges they encounter. Unlike physical games, computer games do not usually exhaust the players from prolonged play-sessions. The players keep engaged and motivated to play even when they fail to accomplish the challenges of the game, and in the process, acquire new skills. The challenges and the skills required to overcome the challenges in the game should be balanced because if the challenges are harder than the individuals' skills, they may feel anxious. If it is more comfortable, they may get bored. Researchers and businesses have exploited this motivation/engagement effect of games by applying game mechanics and dynamics in non-game contexts (gamification) with mostly successful results. Computer-Based Learning is one of the fields that has adopted gamified and game-based solutions to engage and motivate the learners. Motivated students have a more positive attitude and engage better in the learning process (Bergin and Reilly 2005).

Gamification is the use of game elements (such as points, badges, rewards, and leaderboard) in non-game applications (Deterding et al. 2011; Hamari, Koivisto, and Sarsa 2014). Gamified learning tools are usually designed to allow learners to make choices and receive rewards for the right actions (Alsawaier 2018). On the other hand, game-based learning tools are primarily games that are designed to facilitate learning while playing. Some examples of game-based learning software are The Oregon Trail, Blue's Birthday Adventure, Minecraft: Education Edition, and various typing tutors. While game elements add all the novelties to make learning enjoyable, the underlying educational methods are equally important. Game elements and instructional methods work in tandem with each other in educational games. Therefore, it is essential that these two components are balanced out so that the enjoyment does not overtake on learning. Educational games might be played by the students alone or cooperatively with other students, and the setup may or may not have competitive components.

Students learn things better when they get to explore and ask questions (Bonwell and Eison 1991). By asking questions, not only can a student learn new things but also demonstrate the ability to think and debate. A good question can open the door to gaining knowledge and discovery (Vogt, Brown, and Isaacs 2003). As a learning process, course instructors engage students in constructing questions and using those in the class (Yu 2011).

Peer-quizzing is an excellent way to engage students in a class, and since it is informal and does not put them under the pressure of making a mistake that would affect their grades. This also opens room for discussions and debates, similar to the Socratic method (Nelson 1980). In the Socratic method, an argument between individuals by asking and answering questions can lead to critical thinking and discovering knowledge. It is found that students prefer Socratic methods more than traditional class-lectures (Adib-Hajbaghery and Aghajani 2011). Finally, formulating a good question by itself is a skill that is essential in the "understanding" stage of learning (Bloom et al. 1956; Krathwohl 2002). In the "understanding" stage, learners can demonstrate their comprehension by classifying, explaining, summarizing, and comparing the things they learned.

The study presented in this paper is an extension of a previous work (Kiron et al. 2019). We used data collected from our online web-based collaborative peer-quizzing game called "Tower of Questions" (ToQ). The game uses some game elements found in tower defense (TD) games (such as points, building and attacking towers). In the game, students build virtual towers by posing questions, and other students try to attack and conquer the towers by answering the questions. They receive points for asking and answering questions in the form of gems to match TD-themes. The idea behind the game is to engage the students in constructing good quiz-questions and answering those, and in the process, building a crowdsourced question-bank. This approach is known as "contributing student pedagogy" (Hamer et al. 2008), where the students take part in constructing learning materials and provide feedback on each other's work (Hamer et al. 2008; Denny 2013).

High-quality questions from the question bank can be used in class discussions and even in tests for future classes. The question bank also serves as a medium to allow the students to learn about things crowdsourced by their peers and may help them fill in knowledge gaps. Also, the game did not have a leaderboard and instead implemented two pages where the students can observe their progress and support their self-efficacy. The two pages, as shown in figures 1 and 2, respectively, show the questions the students have conquered. On one page, the conquered towers are presented in thumbnails, and the other page shows the conquered towers in tabular form. One of our objectives is to study which type of self-monitoring page is used the most by the students. Also if the students have any gaming strategies or preferences on attacking or building towers in ToQ.

We carried out two studies with ToQ with first-year computer science students. The first study (n=37) took place during one academic term (September to December 2018), and it was found that students who regularly posed quiz-questions also answered other students' quizzes frequently. Also, students who were familiar with TD games tended to answer other students' questions more than posing questions themselves. In this paper, we present the findings of our second study (n=49), which took place in the same class and term but in the year after (September to December 2019). The results show that students enjoyed learning their course materials playing the game and found it useful as a learning tool, which is in line with our previous study (Kiron et al. 2019). In the present study, the students liked answering questions more than asking, and they did not like viewing the questions as much as they liked posing and answering questions. Also, students who used the tabular-based self-monitoring page tended to build more towers than the students who used the thumbnail-based self-monitoring page. This paper is structured into six sections; section 2 discusses related works, and section 3 describes the game we developed and used in our study. In section 4, we discussed the methods, participants, data analysis, and the results of our research. Section 5 and 6 are general discussions and conclusions, respectively.

2. Literature review

Deterding et al. (Deterding et al. 2011) proposed the definition of gamification as *"the use of game design elements in non-game contexts."* Gamification acts as an extrinsic motivator that is designed to influence intrinsic motivations. It is an excellent tool for motivating and engaging people (Kapp 2012; Tanaka et al. 2016). Gamification helps setting up goals (long or short term) and set the focus of the user to achieve that while being entertained (Nah et al. 2013). Two of the most common purpose of both gamified and game-based tools is to motivate and engage people to perform a particular behavior. While engagement is somewhat easier to achieve in a gamified or game-based tool because of its gameful nature, the outcomes of motivation are variable.

The use of gamification and its outcomes depends on how it is designed and used. Domínguez et al. (Domínguez et al. 2013) designed and developed a plugin for the Blackboard learning system to motivate and engage students. They found that the students who used their gamified system did better in practical assignments and had better overall scores than those who did not. However, those students did not do well on written

assignments, and their participation in class activities was less than the participation of those who did not use the system. Denny (Denny 2013) used a badge-based achievement system in their experiment to study its effect on students' participation and contributions. It was found that students who did not use the badges were more active in answering and enjoyed using the system in general and suggested that some other factors motivate their participation.

Many studies reported improved participation by gamifying their systems (Barata et al. 2013; Knutas et al. 2014; Cheong, Cheong, and Filippou 2013). Knutas (Knutas et al. 2014) used an online asynchronous collaborative discussion system to encourage students to help each other and utilized gamification elements (such as points, badges, and leaderboard) to motivate them. Their study (n=249) reported an increase in student collaboration, course communication, and reduced response times. They also found that skilled students were more active and enjoyed using gamification elements.

In another study to see how gamification affects participation, Thom et al. removed the gamification elements from a social network service (SNS) (Thom, Millen, and DiMicco 2012). They conducted the study on a gamified enterprise SNS that awarded points to the users who contributed by submitting contents (lists, photos, or comments) in the platform. At one point in their study, they removed all features related to points (profile badges, leaderboards, and total points display) from the SNS. They found that the removal of those features leads to a reduction of users' contributions to the SNS.

Our objective in the present study is to engage the students in designing and posing quiz-questions as a "contributing student pedagogy" (Hamer et al. 2008) using an online peer-quizzing game. The goal is to engage students in creating questions related to the material and challenging each other to answer these questions, thus exercising their understanding and knowledge of facts about the learning material. It also facilitates the creating of a question bank and allows the students to study the answered questions alongside their course materials (similar to an FAQ). The game is themed with elements found in tower defense games but without leaderboards to encourage the students to focus on self-efficacy and competition.

3.   Tower of Questions – A Peer-quizzing Game

We have used a peer-quizzing game called "Tower of Questions" (ToQ) to engage students in designing questions and answers as a class activity. The game uses styles, mechanics, and dynamics found in Tower Defense (TD) games. TD games are a sub-genre of strategy games; while there are many variations of this genre, the most common implementations involve building structures (usually in the form of towers, fortresses, and castles) and applying defensive mechanisms to prevent attacks by game-AI or by other players. Some popular TD games are Plants vs. Zombies series, Bloons TD series, Kingdom Rush series, and many more. Our ToQ version uses game mechanics such as points in the form of gems, quizzes, domains, and progress and dynamics such as collection, exploration, and community (Bunchball 2010).

ToQ is a web-based game that the students play asynchronously by logging in with their gamer IDs (pseudonyms) and passwords. The front-end implementation uses HTML, CSS, and JavaScript, and the back-end – PHP and MySQL database. Before the game begins, the administrator configures some aspects of the game. For example, creating accounts for the students with the pseudonyms, setting the total number of gems that can be earned from the game in a given period, e.g. by the middle of the term, or for the entire semester. The administrator also configures the number of gems rewarded for building and attacking towers, and the gem-penalties for not playing the game fairly. Only participating students and administrators can access the game, and the quiz questions and answers are based on the course material.

In the game, the students (Lords) build virtual towers by posing quiz questions. For each tower, the students can choose one of the three types of questions available in the game: true/false (TF), multiple-choice questions (MCQ), and short answer questions. Then they select a domain where they want to place their tower in. The domains are the topics taught in the class, but in our game, they represent a zone that the Lords intend to dominate or establish their towers on. When posing a question, the student must also provide the answer. The game has a gem-bank with a finite number of gems that the players can earn by building towers (posing quiz-questions and answers). Players can also earn gems by attacking other students' towers, in which case the gems they earn come from a portion of the gems earned when the tower was built. For example, a student (Lord of the tower) is awarded ten gems for building a tower, and another student (Enemy Lord) attacks that tower (by

answering the question represented by the tower). The Enemy Lord will get six gems from the ten gems, and the Lord of the tower will keep the remaining four. In the case when a tower remains undefeated for seven days, it is made open for all students to view the question along with the correct answer, and the Lord of the tower keeps all the ten gems. The gem distribution is designed this way so that the students think before posing a question and find the reward more valuable because of its scarcity and making collecting points enjoyable (Dichev et al. 2014; Cialdini and Cialdini 1993). Since the number of gems that can be earned from the game is finite, the students can pose questions and answers as long as there are gems available in the bank. If there are no gems left in the bank, no new towers can be built. However, points can still be earned from attacking the open towers. A breakdown of the gem distribution is presented in table 1.

Table 1: Rewards distribution for actions in the game.

Action	Gems
Create a tower	10
Attack a tower	4-6
Flag a tower	0
Being flagged	An increment of -10 gems for each offense

Gems for the TF and MCQ type questions are awarded instantly, but gems for the short questions are awarded after the Lord of the tower has reviewed the answer. The Lord of the tower can mark it as fully or partially correct or incorrect. Since these types of questions are open-ended and sometimes subjective, it is possible that the answer provided by the Lord of the tower and the Enemy Lord may not match fully in arguments and may not address all the points. To address this issue, the game is designed to allow the Lord of the tower to mark an answer to be partially correct. However, to prevent Enemy Lords from guessing, attacks on towers can be marked "partially correct" only up to three times, after which the Lord of the tower can only choose between incorrect or correct.

After a tower is built, it is placed in the "Open Towers" page of the game and is open for attacks by other students. The Lord, who created the tower, cannot attack their tower. A tower can be attacked only once; if it is successfully attacked by one student by providing the correct answer, it is closed for further attacks and is moved to another area in the game called "Conquered Towers" and becomes open for all other students to browse it. The "Conquered Towers" area is the question and answers bank and one of the most important parts of the game. All towers showcased in the "Conquered Towers" area shows the question, answers, and all the attempts made (in case of short questions) when browsed.

While using the game, we were aware that in crowdsourced platforms, the crowd's effort and quantity of contribution might be affected if there are unfair means of earning incentives (Sun and Vassileva 2006; Zhao and Zhu 2014). It is vital to demotivate hyperactive students that attempt to game the system by creating many repeated or trivial questions (Cheng and Vassileva 2005; Mao, Vassileva, and Grassmann 2007). Hence, the total number of gems that can be earned in the game is finite, and the system has a flagging feature to report unfair activities to the administrators who can then take necessary actions to discourage these behaviors. Questions and answers can be flagged by the students when the respective towers are in open or conquered stage. If a question or answer gets flagged by more than 10% of the number of actively playing, it gets moderated. For violations, the first time the student is notified about their action, the gems associated with the incident are taken away from their account and put back to the bank. For subsequent violations, the number of gem-penalty is increased by ten gems plus the gems involved in the incident.

There is no leaderboard in the game because we did not want the students to engage in social comparisons (Hanus and Fox 2015), but instead, we wanted them to focus on the number of gems they can earn from the bank. Self-monitoring helps students to prioritize their learning activities and select the one they find more effective, and it also helps them to manage their time (Zimmerman and Paulsen 1995). Therefore, to allow self-monitoring of their activities and progress, two pages are implemented in the game. The first page, as shown in figure 1, is called "Towers That I Ruled," On this page, all the towers attacked and conquered by the student are displayed in thumbnails with pictures of towers and the question. The second page, as shown in figure 2, is an attack log-book in a tabular form containing more details like the timestamp of the attack, outcome of the attack, and a link to the question.
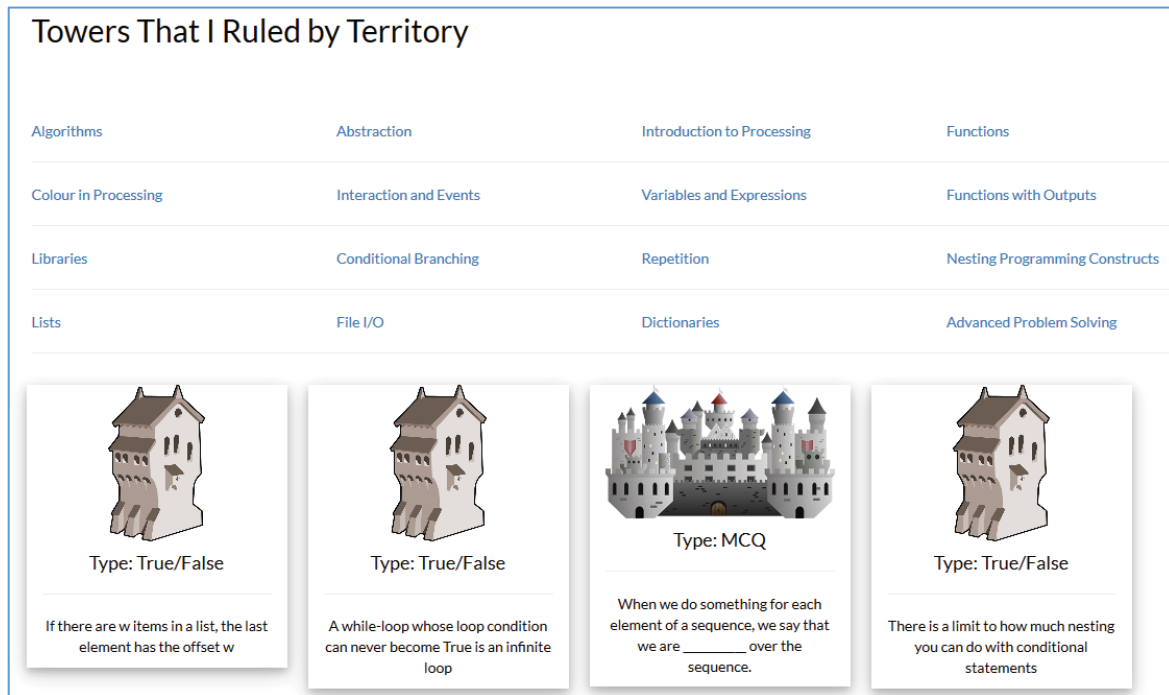
Figure 1: This page in the game shows the students the towers they have successfully attacked and conquered with thumbnails of the questions (towers)

Figure 2: The attack log-book displays all the attacks and attempts in tabular form with timestamps

4. Method

We carried out an exploratory study aiming to answer two research questions:

1. What, if any, gaming strategies did the students deploy in ToQ?
2. What self-monitoring style preferences did the students have?

We collected their game-play data by logging the students' actions and events in the game. We looked for patterns in the data that may reveal in their gaming strategy (build, attack, or view existing towers) that are used

the most and if it had any effect in their grades. We also looked at which of the two types of self-monitoring pages in the game they used the most and if it had any impact in their gem-collection?

4.1 Participants

We recruited 166 first-year undergraduate students taking an introductory computer science course at our University to play the game as a class activity in their introductory programming class in the fall term of 2019. Participation was voluntary, and the students who played the game actively received up to a 5% participation bonus mark. After consenting to participate in the study, the students had to complete a pre-study survey of twelve questions about their gender, preferred study hours, time spent studying, time spent gaming, familiarity with tower defense games, and preference to work alone or in a group. The students played the game for an entire academic term of four months (they played actively for approximately three months, September 4 to December 6, 2019). At the end of the term, the students were invited to respond to a short post-study survey of ten questions, which required them to reflect on their experiences playing the game. The participants were assigned a pseudonym when they signed up for the game and used it to play the game the whole term.

Thirty percent (30%) of the 166 students (n=49) who signed up for the game played it regularly until the end of the term and completed the surveys. Of the 49 students, there were 27 males, 21 females, and one student who identified as "other."

4.2 Results

Together the 49 students created 424 towers (MCQ:171, True/False:172, and Short-Answer:81), of which 167 were built before the mid-term exam (MCQ:74, True/False:52, and Short-Answer:41) and 257 towers between the mid-term and the final exam (MCQ:97, True/False:120, and Short-Answer:40). Of the towers created before the mid-term exam, 159 out of 167 towers (95%) were conquered. The conquered towers of those created between the mid-term and the final exam are 232 out of 257 towers (90%). A summary of the demographics of the active participants in the game is shown in table 2.

Table 2: Description of participants (n=49)

	Description	
Gender	Female	21
	Male	27
	Others	1
Times Towers Viewed **(Viewed Solved Q&A)**	Before Midterm	363
	Before Final Exam	209
Times Self-Monitoring Method Used **(Before Midterm)**	Thumbnail-based page	215
	Tabular-based page	251
Times Self-Monitoring Method Used **(Before Final term)**	Thumbnail-based page	129
	Tabular-based page	119

Before the game session began for the term, we configured the gem bank with 5000 gems. By the end of the term, 4340 gems were earned by the 49 students who played the game regularly. The students posed questions in all the 13 domains except "Advanced Problem Solving." The possible reasons for this are that first, the three types of questions allowed in ToQ are better suited for quizzing facts, concepts, and definitions, as well as simple program tracing examples but do not fit well with solving advanced programming problems. Another reason might have been that this was the last chapter taught in the class, and right after that, the students had their final exam, so they were busy reviewing the entire class material, and they probably did not have time to play the game, even though the game's question bank could have helped them to prepare.

A total of 424 towers were built (424 questions), and 391 of those towers were attacked successfully (391 questions were answered). The students used the thumbnail-based self-monitoring page 344 times (215 times before the midterm and 129 times before the final exam) and the tabular feature 370 times (251 times during midterm and 119 times during final term exam) during the whole game session. The students viewed for studying 572 towers (363 before the midterm and 209 before the final term exam) after they were conquered.

We carried out a correlation analysis between several variables (*midterm exam grade, final exam grade, the final grade for the class, gems earned, towers built, towers conquered, and towers visited*) to evaluate the strength of the relationships. In addition to that, we also analyzed the post-study survey to find out about their experience playing the game and using it as a learning tool.

4.3 Data Analysis

The analysis was carried out on the data generated by the 49 participants who played the game regularly and completed the pre- and post-study survey. We found a stronger correlation between towers conquered and gems earned, $r(47) = 0.855$, $p < 0.05$, compared to towers built and gems earned, $r(47) = 0.331$, $p < 0.020$. This may suggest that most of the students were more focused on earning points by attacking towers than building. Also, we found a strong correlation between towers visited (viewing solved questions) and points earned, $r(47) = 0.610$, $p < 0.05$. The correlation coefficient between towers visited and towers built is $r(47) = 0.400$, $p < 0.004$, and between towers visited and towers conquered, it was $r(47) = 0.541$, $p < 0.05$ respectively. This may indicate that students who visited the conquered towers page were more active in searching for new questions than making questions themselves.

Table 3: Correlation coefficients between midterm grade, final term grade, final grade, gems earned, towers built, towers conquered, towers visited, using thumbnail, or tabular self-monitoring page—correlations where $p < 0.05$ is marked with an asterisk (*)

	Midterm grade	Final term grade	Final grade	Gems earned	Towers built	Towers conquered	Towers visited	Used thumbnail	Used tabular
Midterm grade	1								
Final term grade	0.852*	1							
Final grade	0.855*	0.932*	1						
Gems earned	0.229	0.198	0.281	1					
Towers built	0.121	0.051	0.172	0.331*	1				
Towers conquered	0.162	0.209	0.232-	0.854*	-0.083	1			
Towers visited	0.086	0.139	0.203	0.610*	0.400*	0.541*	1		
Used thumbnail	0.049	0.125	0.138	0.043	0.292*	-0.128	0.015	1	
Used tabular	0.097	0.094	0.108	0.028	0.364*	-0.127	0.188	0.587*	1

When analyzing the correlation between the students' usage of the thumbnail-based page and points earned, and between the tabular-based page and points earned, we found $r(47) = 0.043$, $p > 0.05$, and $r(47) = 0.028$, $p > 0.05$ respectively. The correlation between usage of thumbnail-based page and towers created, and between tabular-based pages and towers created is $r(47) = 0.292$, $p < 0.041$ and $r(47) = 0.364$, $p < 0.009$ respectively. It seems that tabular-based self-monitoring has slightly more influence in the building of towers.

We also calculated the correlation between the points earned and final grade, $r(47) = 0.280$, $p > 0.05$, towers conquered and final grade, $r(47) = 0.232$, $p > 0.05$, towers built and final grade, $r(47) = 0.172$, $p > 0.05$, and towers visited (viewing questions) and final grade, $r(47) = 0.203$, $p > 0.05$. The fact that none of the values are significant may mean that the students' final grades are not influenced by playing the game.

4.4 Result from the Post-study Survey

The post-study survey was completed at the end of the term. It asked about the students' experience using the game and the quality of the questions and answers.

When asked about the quality of questions posed by their classmates, 78.79% of the students said the questions were good. For 12.12% of the students, the questions were too easy, and for 9.09% - too challenging. When asked if they found it enjoyable to learn their course materials using the game, 75.76% responded "yes" and 24.24% – "no." In response to the question if ToQ was useful as a learning tool, 78.79% said "yes" and 21.21% – "no." Regarding which features in the game they liked the most from the multiple-choice options, the most (48.48%) chosen option was "Answering the questions," and the least (12.12%) preferred option was "Reading from the question bank." A graph of which features are liked the most by the students is presented in figure 3.
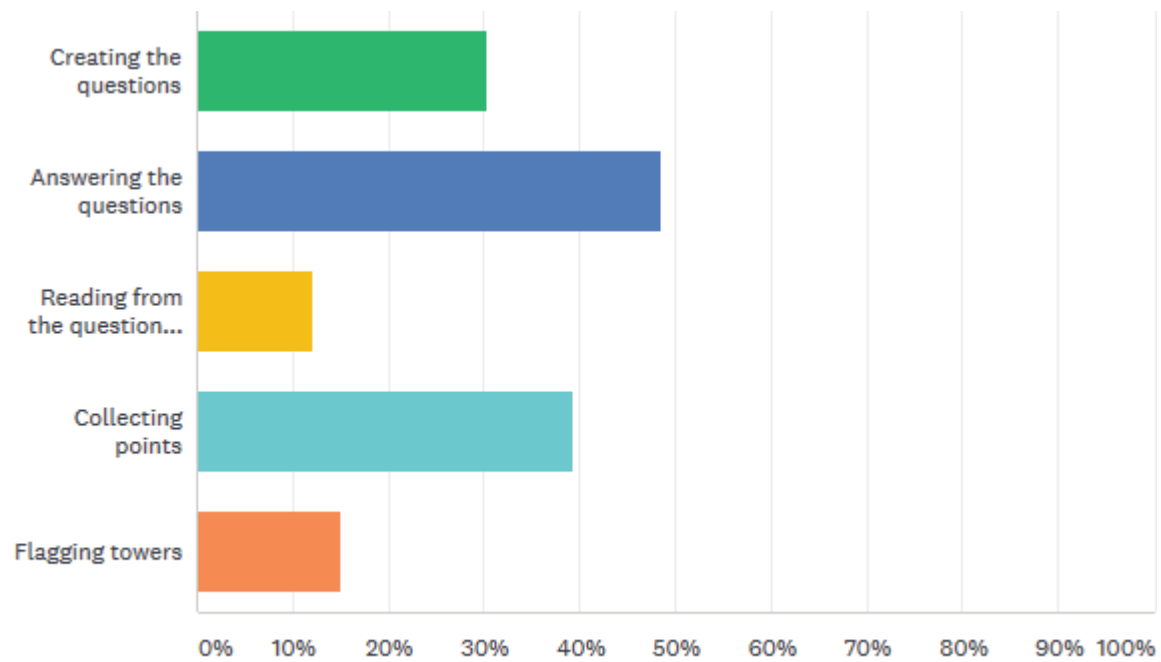
Figure 3: Post-study survey result of the multiple-choice question - Which features of the game the students liked most

When asked about which features they think need improvement, a lot of the responses were about not having enough questions to answer. Some of the feedback is highlighted below:

1. "There often were not open towers to attack. Sometimes the questions people posted were worded in a confusing way."
2. "Pre-built question in case there's no question available."
3. "Not enough questions to go around."

When asked if they have any other feedback for the game, one student wrote:

"I think this was a cool learning tool. It has room for improvement but I think if the Q/A are reliably accurate, it can be a good study tool as well. A little competition never hurt either, so maybe something like a daily or weekly bonus question for some reward would get people on it more often, and even more competitively if only a certain number of people could get the reward for answering. That sounds maybe a bit complex, but I'd participate in that on an ordinary non-terrible non-midterm week!"

Another student wrote:

"Moderation of the questions (answered questions don't get updated quickly enough, and some people are bad at presenting questions) and making the UI easier to navigate (I couldn't find where to ask/answer questions for the first week)"

From all the feedback, it appears that the students enjoyed collecting points, and they preferred to have ready-made questions in the bank for practicing. The quality of the crowdsourced questions seems to be concerning to the students. This may explain why reading the questions from the question bank consisting of the answered questions had the lowest votes in the post-study survey. Even though there was a flagging option that allowed students to mark spam or trivial questions in the game, it was not used by the students as much as expected. Results from the post-study survey, as shown in figure 3, show that answering the questions, collecting points, and creating towers are the three most liked features of the game.

5.   Discussion

Gamification and game-based learning have a promising future. The design of the gamified and game-based applications plays an important role in its success. We explored how students play a peer-quizzing game themed as a tower defense game and which actions (building, attacking, or visiting conquered towers) they prefer to take the most. Also, we wanted to find out which of the two self-monitoring pages (thumbnail with tower icon

and the text of the question or a tabular form with more details like attack success/fail, link to question and timestamp) was used the most as a reflection/self-monitoring tool, in the absence of a leaderboard. In addition to that, we also analyzed the post-study survey results to evaluate the experience of the students from playing the game.

Results from the correlation analysis suggest that the students gave more emphasis on earning gems by attacking towers, which is in line with the results from the self-reported post-study survey where answering the questions turned out to be the most liked part of the game. The students enjoyed collecting the gems and playing the game in general, as reported by researchers in previous studies about games in education (Denny 2013; Domínguez et al. 2013). In the process, we did manage to collect quiz-questions and answers and build a question bank by the students. However, we found from the data analysis that playing the game did not affect the students' overall grades. This finding is in line with other studies, e.g., one conducted by Frost, Matta, and MacIvor (Frost, Matta, and Macivor n.d.). The question bank can potentially be a useful learning resource in preparation for the final exam. However, most of the students did not find it an enjoyable activity to look through the question bank (as shown in figure 3). It is also possible that the quality of questions and answers was not perceived as sufficiently high to be used as a learning resource, as suggested by the answers of 22% of the students, stating that the questions were either too easy or too hard. Future work will evaluate the quality of the questions and answers collected in the game during this study.

Our study was limited in several ways. First, the game was used in a first-year programming language course that had lectures and lab classes. ToQ was designed to work with theoretical quiz-questions that are short and to the point. These questions did not address the practical part of programming language courses. Developing programming skills is an essential part of programming classes, and programming tasks have a higher weight in the evaluation of student performance.

Second, not all the students who signed up for the game played it evenly; some students were more active than others. In addition to that, the number of students who fulfilled all the requirements (completing the pre and post-study survey and playing the game) was significantly smaller (n=49) than the number of students who signed up for the study (n=166).

Third, because of the hybrid nature of gamified systems (neither a 'pure' functional software nor a "full-fledged" game), they are prone to cheating based on the game elements included in their design (Deterding et al. 2013). In ToQ, there was a possibility for students to collude to earn points by posing and answering questions even though they were told not to disclose their pseudonyms. Also, the surveys were self-reported; we did not use a standard tool or scale to measure their degree of enjoyment and engagement.

Other ways of gaming the system involved spamming/submitting trivial questions. We had envisaged that possibility and added the Flagging feature that allowed students to report such poor-quality questions. Since the game entirely relied on crowdsourced actions, and we did not plan to interfere with the students, it was not possible to determine and filter out all the poor questions. We also did not use any measures to moderate the students' gaming activity, such as obtaining questions from online repositories and power-gaming (Edery and Mollick 2008). The flagging feature was not used by the students as expected. We only received a few flags (15 before the midterm exam and 17 between the mid-term and final exam). Future work can explore awarding gems for policing the tower building process, i.e., creating rewards for players for moderating the quality of questions, using an adaptive rewards mechanics similar to the one in (Cheng and Vassileva 2005).

The game's user interface was straightforward and aesthetically not so appealing; it would be good to provide a more aesthetically pleasing GUI. Finally, a redesign of the concept of towers and attacks can be carried out to make the game more suitable, especially for learning the use of a programming language for problem-solving. The design of the game, along with all the elements, will likely require a revision, e.g., using quests and collaborating teams of attackers to conquer a problem.

In the near future, we plan to repeat the study in a course more suitable for the game like an online university course with more factual and theoretical materials. We will be looking for more sophisticated ways to control the quality of the questions (e.g., applying lexical and semantic analysis). Last but not least, we also plan to add tools to the existing game to facilitate the submission of short coding quizzes, as seen on various online programming websites.

6.   Conclusion

In this study, we used a peer-quizzing game to engage students in generating quiz-questions and building a question bank in the process. A total of 49 students played the game regularly over an entire term (3 months) and participated in both the pre- and post-study surveys. From our study, we found that generally, the students enjoyed learning their course materials in this way and found the game useful as a learning tool. The students enjoyed answering the quiz-questions and earning points.

The students used the two self-monitoring pages in the game almost with similar priorities. The tabular-based self-monitoring page has a stronger correlation with building new towers compared to the thumbnail-based self-monitoring page. In general, the two self-monitoring pages might have been used by the students to view their conquered questions mainly.

In the future, we would like to conduct the study in a different course, preferably a course with more theoretical content. Since the flagging option was not used by the students as expected and because they loved collecting gems, we would like to incentivize that to increase participation in moderations.

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Appendices

Appendix 1: Pre-study survey questions

1. Please enter your ID

2. Gender
Male
Female
Other

3. Do you play video games in any platforms (PC, Mobile, Console etc.)?
Yes
No

4. How many hours do you spend playing games each week?
0
1-4
5-10
11-15
15+

5. Are you familiar with Tower Defense Games?
Yes
No

6. If you answered YES in the previous question, name some Tower Defense games you have played.

7. Do you submit your assignments in time?
Strongly agree
Agree
Neither agree nor disagree
Disagree
Strongly disagree

8. How many late assignment submissions do you have in the last 6 months?
I am a freshman
None
1-2
3-5
6-8
8+

9. Do you like to work alone or in a group?
Alone
Group

10. What's your ideal group size?

11. What is your most preferred time for studying?
8am-12pm
12pm-4pm
4pm-8pm
8pm-12am
12am-8am

12. How many hours do you study each week?

1-3
4-10
11-15
16-20
21-25
25+

Appendix 2: Post-study survey questions

1. What is your ID?

2. How did you find the questions your classmates asked?
Not challenging
Too easy
Good
Too challenging

3. Do you think it was fun to learn your course materials in this way?
Yes
No

4. Do you think Tower of Questions was useful as a learning tool?
Yes
No

5. Which feature(s) did you like the most? (multiple items)
Asking the questions (creating towers)
Answering the questions (attacking towers)
Reading from the question bank (viewing conquered towers)
Collecting points
Flagging towers

6. Do you want to try the system in other courses?
Yes
No

7. If you answered yes in the previous question, please tell us the name or code of those courses (separated by comma)?

8. Which feature(s) do you think needs improvement?

9. What is your overall experience with the game?
5-star rating scale

10. Any other feedback you would like to give us.