Engaging Computer Science Students through Gamification in an Online Social Network Based Collaborative Learning Environment

Cen Li, Zhijiang Dong, Roland H. Untch, and Michael Chasteen

***Abstract*—Gamification is the use of game mechanics such as rewarding points and achievement badges to engage target audience and encourage desired behaviors. Gamification has gained a great surge of interest in recent years as an effective approach to engage existing users and attract new users to web sites. In this paper, the use of gamification in engaging Computer Science students in an online social network based collaborative learning environment, called PeerSpace, is discussed. PeerSpace integrates a suite of Web 2.0 tools that promote student interactions on course-related topics as well as purely social matters. The design and implementation details of various gamification schemes are presented. An assessment of the effectiveness of the schemes is discussed.**

***Index Terms*—Gamification, computer science education, computer supported collaborative learning, games, CS1 and CS2.**

I. Introduction

PeerSpace is an online learning environment developed to enhance student learning by encouraging and facilitating the building of peer support networks among students enrolled in entry level Computer Science courses [1]. It is believed that peer networks enable the students to support each other both socially and academically and to help the students in dealing with common difficulties such as stress and isolation [2]. In addition, peer networks serve as a solid foundation for effective peer collaborative learning. With strong peer support, the students will be more comfortable and willing to share knowledge and experiences, exchange ideas, and seek help. Carefully designed learning activities in PeerSpace, such as peer code review, group wiki-based exercise, and self-paced quizzes in preparation station encourage students to help each other and learn from each other.

While PeerSpace has been used by students with much success both in terms of improving student learning and in promoting a stronger sense of learning community and a stronger peer support network [3]-[4], it has also been observed that the student usage of PeerSpace is not as voluntary and active as was hoped for. Even though there is a group of students actively participating social activities in PeerSpace by posting helpful, useful, and/or insightful posts, and join in discussions, there are also students who participate PeerSpace activities mainly because they are required as part of the class assignments. Analysis of data collected from controlled experiments show that there is a direct, positive relationship between the amount of usage of PeerSpace and the benefit gained from this learning community [4]. The question for us is "How to better engage the students in PeerSpace social and learning activities?". This paper describes our approach to this question by introducing game mechanics to promote the students' learning by encouraging them to:

- participate more in social and learning activities,
- develop a stronger sense of community, and
- be more willing to help each other on academic and social matters.

The approach we took is called "gamification". Gamification uses game mechanics, dynamics, and frameworks to promote desired behaviors. Gamification attempts to harness the motivational power of games and apply it to real-world problems [5]. It is a new concept but has received very warm welcome by many companies, such as Google, Groupon, Photoshop, Pandora, FourSquare, Zipcar, Steam, etc. These companies used gamification features in their web sites to better engage their loyal customers and to attract new customers to their sites [6]-[5].

In this work, we present how gamification may be applied for education purposes to better engage Computer Science students to participate in social and learning activities in an online learning environment. A number of gamification features were added to PeerSpace to reward the students for performing social activities, help them make new friends by playing turn-based games with different students, and to engage in peer-learning and peer-tutoring activities.

Section II presents the background information of PeerSpace and gamification used for education. Section III discusses the various gamification features that have been implemented in PeerSpace. Section IV discusses the preliminary experiments and results obtained in assessing the effects of the gamification features in engaging students. Section V presents the conclusions of this work.

II. Background

A. PeerSpace

Developed as a social network based collaborative

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learning environment for Computer Science students, PeerSpace implements features that facilitate peer collaborative learning as well as social interaction and the building of peer networks among CS students [3], [1]. The goal is to improve student motivation in learning through the building of supportive peer networks [2]. The learning related features include:

- Peer review, where students review other students programs and provide constructive comments and feedbacks [4];
- Preparation station, where students can work on multiple choice and true/false questions related to the course material and receive immediate feedback;
- Project repository allows the students to electronically submit the assigned programs, view the status of the submission, as well as retrieve and view the graded assignments, and
- Group based wiki allows the study group members to collaboratively create/edit documents.

The social activity related features include:

- User profile: Students may edit their profile information such as the profile icon, hometown, graduating high school, music and sports interests, contact information, and personal web links;
- Friends: Students can request/add other students to be their friends;
- Personal blogs: Students may post blogs with multimedia content or comment on other students' blogs;
- Groups: Users may create groups or join existing groups. The group forum discussion feature allows private discussions among group members;
- A custom-built forum discussion module that allows hierarchical threading and thumbs up and down voting; and
- A built-in online chat system.

Once logged in, a student is presented with the PeerSpace dashboard. The dashboard is designed to show the current community status, e.g., latest blog and forum posts, online users, list of friends, and group membership; as well as acting as a launching platform to various learning and social activities [1]. Fig. 1 shows an example dashboard.

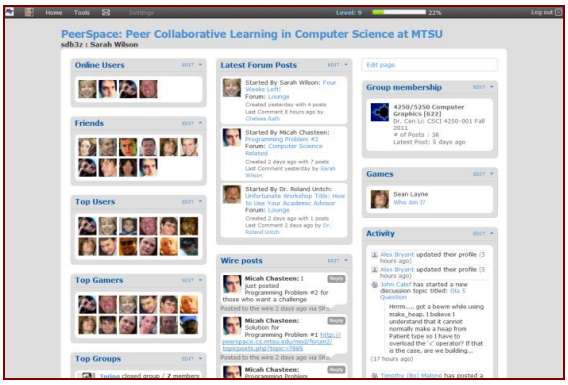

Fig. 1. The Peerspace dashboard

B. Gamification Used in Education

The idea of using games for education has been around for a while. Klopfer *et al.* argued that: (1) games can engage players in learning that is specifically applicable to "schooling" and (2) there are means by which teachers can leverage the learning in such games without disrupting the worlds of either play or school [7]. The Scratch software, developed by the MIT's media lab, is one such successful example [8]-[9]. The idea of gamification for education is relatively new. Vandenberg successfully uses gamification to teach high school math by having the students play Monopoly [10]. Landers applied gamification schemes to get the undergraduate psychology students to work on extra homework voluntarily [11]. Doyle taught media literacies to middle school students by letting them play computer games 0. Lee & Hammer and Rock discussed the benefits of gamification in engaging students in learning and strategies for effective gamification in education [13]-[14]. Direkova discussed 16 design patterns used for effective gamification development [15], for example, let users earn points and badges for site activities, provide tutorials and coaching to get user started, provide mechanisms for users to give social feedback, reward users for inviting friends to the activities, enable establishment of user reputation, and sharing achievements among users and friends. Many of these ideas have been used in designing and implementing gamification features in PeerSpace.

III. Gamification in PeerSpace

Several game design techniques have been implemented in PeerSpace to encourage participation in social and learning activities. They are PeerSpace participation points, a level system based on participation points, a progress bar, leader boards, collaborative programming for community building, and casual games. This section describes the design and implementation of these game mechanics in PeerSpace.

A. Casual Games

PeerSpace games provide students with the ability to participate in a fun social activity that they are familiar with and understand. Students can start a game with either a chosen student or a computer-random-selected student; and then play in real-time or asynchronously over a longer period of time. Students can have multiple active games at the same time.

Currently, four 2-person, turn-based games have been deployed: (1) Tic Tac Toe, (2) Four in a Row (aka Connect Four), (3) Go fish, and (4) Who Am I? The first three games are quite familiar to most people. The "Who Am I?" game is developed based on the children's game "Guess Who". In "Guess Who", each player starts with a set of cards with face images of 24 different persons. Each player selects 1 of the 24 persons as the game person for the opponent to guess. During the game, at each turn, each player asks one question about the person they need to guess. An example question would be "Does this person wear glasses?". The other player is required to provide a true answer to the question. The objective of these questions is to eliminate candidate persons and identify the person to be guessed. The game has been modified in PeerSpace. Instead of a fixed set of 24 images used in each game, the images are randomly selected from the profile images from all the PeerSpace users. This includes

both faculty and staff members in the department as well as all the student users. In addition, the information provided by the PeerSpace users in their profile, e.g., one's high school and hometown, are included as part of the game. Questions may be asked about these as well. A big advantage of having this game in PeerSpace is that the students, especially freshmen, have the opportunity to quickly get acquainted with faculty and staff, as well as other students in the department. A second version of "Who Am I?" has been created where the person to be guessed are famous computer scientists. Information such as the contributions of these scientists to the field of CS have been compiled and added. Fig. 2 shows a snapshot of two players in the middle of a Connect-Four game and Fig. 3 shows a snapshot of the "Who am I?" game.

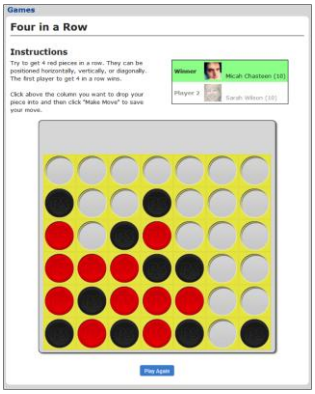

Fig. 2. A snapshot of the game board of "four in a row"

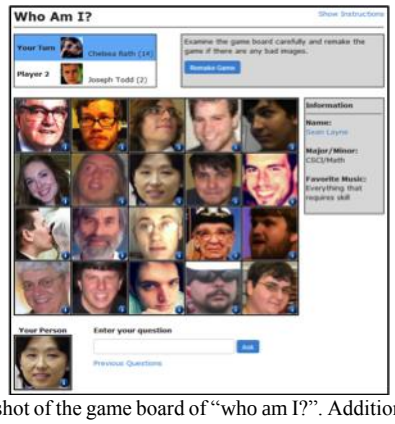

Fig. 3. A Snapshot of the game board of "who am I?". Additional information of selected icon is displayed in the grey box on the right side.

B. Participation Points

One basic design pattern for gamification is that users can earn points for their active participation in activities. Point system has been implemented in PeerSpace to tie student activities that lead to contributions to the learning environment with points. Students earn points for engaging in social activities, such as creating/commenting forum and blog posts, and playing games with other students.

A student earns 100 points for every new forum topic, blog post, or comment to an existing article. A message pops up showing the points added for the student. This gives instant reward to the user creating the post.

In game playing, the amount of points earned is mainly based on participation. To encourage the students to play with many different students in PeerSpace, (leading to new social connections with new students), the point system discourages the students from playing with the same students on the same games. When two students continue to play the same game against each other over and over, the number of points they can earn on each game decreases. The calculation of points is based on a transformed sigmoid curve. The decrease in points is slow initially and drastic after some point.

Since the main purpose of the games is to attract the students to PeerSpace and become more active in PeerSpace, the point system is built with an emphasis on participation than winning or losing the games. In particular, both players get the same amount of points for participation in playing the game to completion.

C. Participation Levels

Participation points earned by each student is also linked to promotion in a level system. The level system developed acts as "badges" for active users of PeerSpace. When a student earns a certain amount of points, (s)he is promoted up to the next level. The level of a student is displayed prominently in the status bar of every page the student visits in PeerSpace. Immediately to the right of the student's current level, a progress bar shows the progress the student has made towards being promoted to the next level. In addition, the level of the student is displayed on every blog or forum topic the student posts. This allows all PeerSpace users to see the level of each student when (s)he add a new post. These activities build a student's reputation. Fig. 4 shows an example on how the points and level for one student is displayed in PeerSpace.

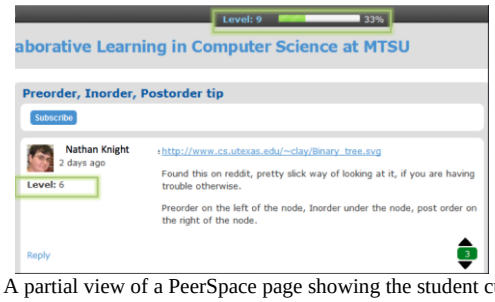

Fig. 4. A partial view of a PeerSpace page showing the student currently logged in has a level of 9, and is 33% completed towards the next level of 10. The student who posted the new forum topic has a level of 6.

D. Leaderboards

Leaderboards feature top users and groups that have a high rate of participation, as shown in Fig. 5. There is also a game leaderboard which displays the students who have won the most games, see Fig. 6. These boards are shown in the homepage after each student logs into PeerSpace. It provides a strong incentive for the students to be more active in participating in PeerSpace activities and to play more games.

E. Collaborative Programming for Community Building

To Computer Science students, one shared interest is writing computer programs for competition style problems. To engage the students, a sequence of forum topics was created where an ACM programming contest type of problem is posted. Any student, or group of students, in PeerSpace may post their solution to the problem as comments to the discussion topic. The students interested in the problem get to look at other students' solutions, provide comments and

feedback, as well as suggestions to other solutions. This provides an excellent way for the students to participate, collaborate, advance their level, and more importantly learn programming skills from each other. These forum topics generated great turnout from the students. This gamification feature makes it fun for the students to try out programming contest type problems, receive coaching from fellow students, as well as generate interest among students in using PeerSpace. Fig. 7 shows one such topic and the comments (with solutions and suggestions) from the students.

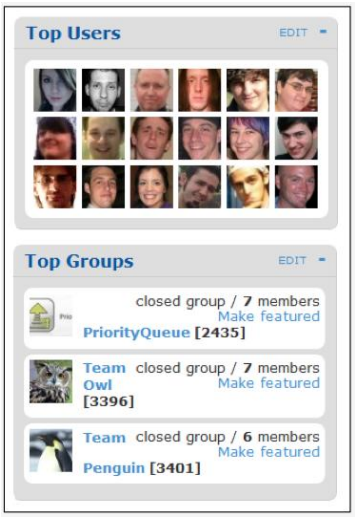

Fig. 5. Leaderboard showing the most active students having the highest points, and the most active groups having members earned the highest average points.

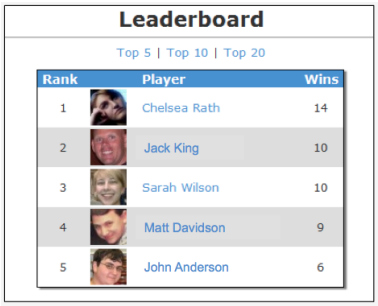

Fig. 6. The Leaderboard showing the top game players.

IV. Game Development

To facilitate the development of different games in PeerSpace by different developers over time, and to ensure the games are developed with a uniform look. A common framework was developed that can be used when creating new games in PeerSpace. The framework includes a library of functions that supports the back end functionality to store and retrieve relevant data about games and players that are stored in the database, and a front end that provides a consistent game, e.g., an interface to display the game board and to show the turn of the players. Fig. 8 presents an overview of the features developed in the main components of the game framework.

A. Back End

The library of functions in the back end performs administrative tasks, retrieving game information and player information, as well as handling various end-of-game situations. For example, functions have been developed to:

- Retrieve all the students who would like to be selected for a game match. This is used in the beginning of each game for a student to try to select another student to play against.
- Determine who won the game and calculate game points to be awarded to the two players. The game points are computed based on the number of games that have been played between these particular two students in the past.
- Terminate a game if a player has not made a move within a pre-specified time or a player decides to withdraw from a game.
- Retrieve all the players sorted by their game win counts and by game type.

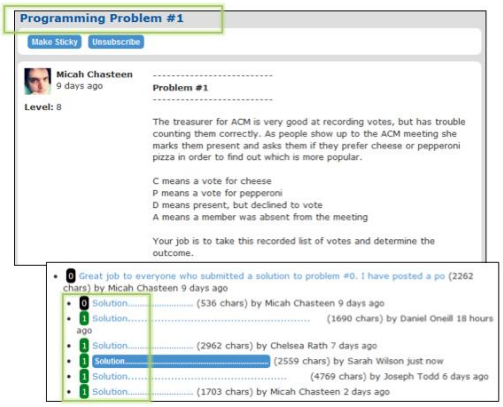

Fig. 7. Forum discussion on competition style programming problem

Fig. 8. An overview of the game framework

B. Front End

Each game has a different game board. But the supporting features on the game interface are made in the same format for different games. This gives a uniform outlook when the students play different games in PeerSpace. For example, on top of each game page, the same window layout is used to display the players as well as each user's total games won. During the game, the player who should be making the next move is highlighted blue, and at the end of the game, the winner is highlighted green as shown in Fig. 9.

Fig. 9. Display of the players in the game, as well as the winner of the game

V. Experimental Analysis

The gamification features received very positive feedbacks from the students. An overall greater number of activities have been observed. To study the effects of games in PeerSpace in terms of attracting students to PeerSpace and encouraging students to be more active in PeerSpace, a controlled experiment was performed. Students from two sections of Computer Science II (CS2) participated in the experiment. Students in the two sections were taught by the same instructor and used the same textbook and assignments. Students from both sections used PeerSpace. Students in the control section did not use the game feature in PeerSpace while the students in the experiment section played the games. The observation period is 6 weeks. The number of posts created by each student in the control and experiment groups during this time period were collected and compared:

- On average, each student in the experiment group played 2 games;
- The experiment group generated a total of 91 posts during the observation period, while the experiment group generated a total of 265 posts. This makes the experiment group generating nearly 3 times the posts than the control group students;
- PeerSpace games increase site activity in students. Fig. 10 plots the relation between the PeerSpace points earned and the number of games played by students in the experiment group. On average, 3 additional posts are made for each PeerSpace game played.

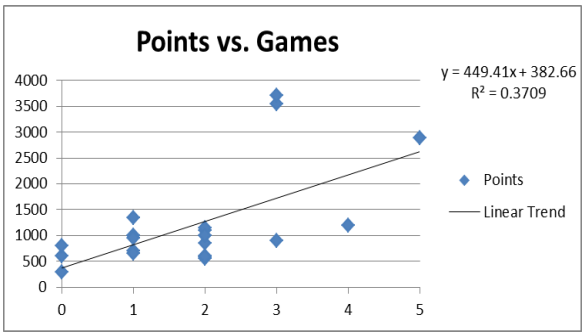

Fig. 10. Relation between the PeerSpace points earned and the number of games played for students in the experiment group.

VI. Conclusions

This paper describes the addition of gamification features to an online social network based learning environment to better attract and engage students in collaborative learning. Preliminary results show students have responded to the new game mechanics and became more active in social activities in PeerSpace. A longer observation time is needed to fully understand the impact of these gamification features.

Gamification is a new concept. Initial success has been reported by a number of companies in their attempt to attract more customers to their web sites and to engage the existing customers to stay active at their sites. Gamification used in education is still in the infant stage. The idea has a lot of potential in motivating students to be more active in participating in online learning environments and collaborative learning environments.

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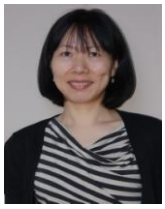

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He worked as a Graduate Research Assistant at Middle Tennessee State University aiding in the research and development of PeerSpace. He currently works as a Software Engineer at Google in Irvine, CA. His research interests are centered around social and gamification as well as user experience

Mr. Chasteen is a member of ACM and has actively participated in many events. He took first place on-site at the ACM Mid-Central USA programming content in 2010 and in the master's category at the ACM MSE conference in 2012. He also received the Paul Hutcheson Computer Science Graduate Scholarship for outstanding performance in computer science.