PeerSpace: An Online Peer Collaborative Learning Environment for First Year Computer Science Students

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Abstract: Dropout and failure rates in introductory Computer Science (CS) courses are distressingly high. It has been observed that, success in CS courses improves when students form effective peer support networks. Unfortunately students are often unable to create such support networks on their own and educators have had few tools at their disposal to help promote the formation of such peer support networks. This paper discusses an integrated peer collaborative learning environment, called *PeerSpace*, developed to help educators help students form peer support networks, increase motivation, and ultimately improve learning. In addition to online learning tools developed for CS education, social components such as forums, blogs, wikis, groups, and chat, are integrated into *PeerSpace*. Comparative studies were conducted to measure the effectiveness of the system among students taking CS1 courses. Preliminary results from these studies suggest that *PeerSpace* was successful in building peer support networks and gave positive impact to learning outcomes.

Introduction

Among the factors dragging down success rates in CS courses, counterproductive student attitudes have been one of the most difficult for educators to effectively confront. Studies of students in introductory computer science (CS) courses reveal problems with: combativeness towards the opinions of peers, unwillingness to support or aid others, procrastination on assignments, disdain for working in groups, and a lack of motivation, persistence, and passion towards the course material (Kinnunen & Malmi, 2006; Waite & Leonardi, 2004). As a result, dropout and failure rates as high as fifty percent have been a common phenomenon in introductory CS courses (i.e., CS1 and CS2) nationwide (Kinnunen & Malmi, 2006).

Previous research in education suggests that to enhance student motivation, persistence, and the willingness to work collaboratively, it is necessary for the students to develop a network of support, especially support provided by their peers (Kinnunen & Malmi, 2006, Waite & Leonardi, 2004). However, students find it difficult to create and maintain such support networks on their own. Helping students create such peer support networks is a task educators must shoulder. It has been shown that interacting with peers fortified the learning process and made learning more enjoyable (Perez-Prado & Thirunaraanan, 2002; Swan 2002).

To help educators to help their students, we have developed an online social network learning system called *PeerSpace*. *PeerSpace* integrates a suite of Web 2.0 tools to promote student interactions. Using *PeerSpace*, students are able to communicate with each other synchronously and asynchronously on course-related materials as well as social matters. The virtual environment provides an improved vehicle that better suits the busy study and work schedules of today's college students. It expands student interactions and activities beyond the face-to-face classroom to the online environment and provides infrastructure to help students build peer support networks. Beyond social networking, *PeerSpace* provides specific tools for conducting peer collaborative learning activities. Peer collaborative learning refers to the use of teaching and learning strategies in which students learn with and from each other without the immediate intervention of an instructor (Boud, Cohen, & Sampson, 1999). Studies report that peer learning promotes greater conceptual and procedural gains for students, accommodates a broad range of learning styles, results in greater enjoyment of the learning task, and encourages a stronger persistence in learning.

Related Work

PeerSpace is developed based on earlier work done on Peer Collaborative Learning (PCL) applied to computer science education and developments in Computer Supported Collaborative Learning. In PCL, student learning is enhanced through peer/classmate interactions that occur when students discuss course-related materials and complete assignments as a group (Beck & Chizhik, 2008), teach each other course-related materials (Huss-Lederman, Chinn, & Skrentny, 2008). PCL techniques have been used in introductory computer science courses resulting in reports of higher student achievement, more positive attitudes toward the subject, improved student retention, improved student interaction and communication skills.

One focus of work in Computer Supported Collaborative Learning (CSCL) has been to develop, adapt, use, and assess online tools that support collaborative learning. Online communication tools, such as online discussion forums, blogs, and wikis, and real-time chat rooms, have been adapted and investigated as ways of promoting collaborative knowledge building among students (Bhagyavati, Kurkovsky & Whitehead, 2005; Lee, 2006). Researchers have found that online discussion enables students to participate in collaborative sharing and creating of knowledge. Being involved in an online discussion group improves communication and collaboration skills, encourages lifelong learning (Barker, 2003), increases student participation and achievement of learning outcomes, accelerates the generation of learning communities (Bhagyavati, Kurkovsky & Whitehead, 2005) and leads the knowledge construction process to higher phases of critical thinking (Aviv et al; 2003). Blogging improves student comprehension because they must "synthesize information, formulate additional questions, contrast and make sense of differing viewpoints, and identify patterns and trends" (Karrer, 2007) when posting information. Wikis transform the one-to-many model of knowledge transfer into a collaborative, many-to-many network where students, teaching assistants, instructors can contribute to the knowledge of the group.

A second focus of work in Computer Supported Collaborative Learning is centered on developing and assessing strategies for building online learning communities. An online learning community (Goggins, Laffey, & Tsai, 2007; Misanchuk, 2001) is a group of people, sharing some set of common values and beliefs, who are actively engaged in learning together from each other on the web. To "build" an online learning community is to build the students' sense of community, social identity, and trust through some form of group activities (Ching et al., 2005).

The *PeerSpace* System

A premise of *PeerSpace* is the belief that combining the methods and tools of PCL and CSCL will have an even stronger positive impact on student learning than either alone. By doing this, peer collaborative learning activities developed for CS education can be extended from the physical to the online world. This consequently minimizes scheduling costs, the amount of time and effort needed to organize face-to-face group meeting, that are often quite high in typical introductory CS courses due to the large percentage of the students working many hours off campus. In addition, the ideas of online social networks can be incorporated into the integrated system to enhance student interactions and facilitate the building of peer support networks among students. In such a system, peer collaborative learning activities encourage students' participation in the online social networks, whereas online social networks make it easier for students to support each other academically and socially.

The goal of *PeerSpace* is to promote peer collaborative learning in introductory CS courses by providing carefully designed peer collaborative exercises within a friendly, peer-supportive online social network environment, and to facilitate the building of peer support networks that last throughout and beyond the introductory CS courses. The *PeerSpace* system has two main components: a social network component and a peer-learning component. The social network component enables the building of peer networks and trust, and fosters a feeling of learning community membership---these are essential elements for effective collaborative learning. This component provides a variety of tools to support asynchronous and synchronous peer communication.

The collaborative-learning component is comprised of a set of carefully designed peer learning activities that include group discussion, peer tutoring, and peer assessment. The shared knowledge these activities instill affords the students a deeper understanding of course-related concepts and a broader knowledge of course-related topics. Moreover, these collaborative peer-learning activities strengthen the support among peers and expand a student's social network.

PeerSpace is developed based on Elgg (www.elgg.org), an open source social network engine. The *Elgg* engine comes with a number of basic features, some of which are directly incorporated into *Peerspace*. These include:

- User profile: Allows students to share their personal information such as the profile icon, interests, email, and personal web links;
- Friends: Allows students to build a personal network of peer support;
- Personal blogs: Allows a student to share their thoughts and opinions with either friends or the whole *PeerSpace* community;
- Groups: Allow group members to have private discussions.

To make *PeerSpace* an environment to foster a strong sense of community, a number of new features have been developed as additional plugin modules:

- Scoring for *PeerSpace* community contribution: To keep track of student contribution to the community, a scoring module is built that gives 1 point to each post/comment a student submits in discussion forum or blog. A logged-in student can view his and group members' contribution;
- Widgets are developed to encourage friendly competitions among individuals and groups. The list of "top" students, i.e., students with the top community contribution scores; and the list of "active" groups, i.e., groups with the highest average member contribution scores are displayed on the front page of *PeerSpace*;
- A custom-built forum discussion module that allows hierarchical threading and thumbs up and down voting;

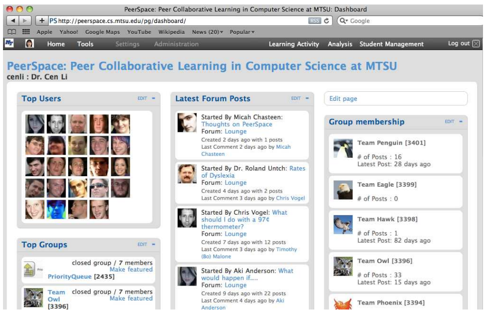

Figure 1. A Snapshot of the Front Page of *PeerSpace.*

- Real-time peer-to-peer chat and group chat; and
- RSS feeds from various *PeerSpace* tools, and RSS subscriptions.

To promote collaborative learning, a number of modules have been incorporated, adapted, and developed for various learning activities. The group wiki plugin has been adapted to allow the study group members to collaboratively design algorithms for group programming assignments. It has also been used for group homework assignments consist of short answer questions and coding exercises. To help students understand basic concepts covered in lectures, a student practice exercise module is built to allow students to work on multiple choice questions and true/false questions addressing the concepts. It also serves as a tool for the students to prepare for the semester tests. The students are encouraged to seek help from their group members or from *PeerSpace* community on questions concerning these exercises. A project repository module has been developed where the students can electronically submit assigned programs, as well as retrieve and view the feedbacks from instructors in *PeerSpace*.

When a student logs in *PeerSpace*, the student is presented with the *PeerSpace* front page, shown in Fig. 1. The front page displays the current community status in the form of the latest blog and forum posts, current online users, and group membership information. Also displayed are items designed to promote collegial competition among students: ranked listings of the top students and the most actively participative groups.

The concept of "group" is an essential feature of *PeerSpace*. It brings students with similar backgrounds and interests together, and gives them a private place for discussion and collaborative work. Group members may choose to use group discussion forum, group blog, or group wiki for their work. *PeerSpace* groups are either created by instructors for lecture/homework purpose, or created by students themselves for social purpose. An Elgg plugin called DokuWiki is incorporated by *PeerSpace*. This allows each group to construct their own wiki pages. The wiki tool enables instructors and group members to track revision history of the document maintained by the group. The DokuWiki tool also provides the built-in "code block" feature that provides an IDE-editor like view of source code for different programming languages by preserving the format and the color pattern. With the support of DokuWiki, it is easier for group members to work collaboratively on a document that may contain the solution to group homework; and instructors and group members can easily identify the contribution from each group member and observe the discussion process of constructing the solution.

Experiment

In evaluating the effects of using *PeerSpace*, there were two facets we wished to examine in particular:

1. the effectiveness of *PeerSpace* in helping the students avail themselves of a peer support network where students help one another and work collaboratively in small groups on class assignments; and
2. the effectiveness of this collaborative learning environment in better motivating the students and in improving student learning of course material.

During the Fall 2010, a preliminary experiment of *PeerSpace* was conducted on two CS1 sections that were taught in the traditional lecture format by the same instructor using the same textbook. One section of 23 students is designated the experiment group, and the other section of 20 students is the control group. The students in both sections have been put into study groups of 5-7 members. The groups were formed by the students voluntarily at the beginning of the semester. The students in the experiment section were exposed and required to use *PeerSpace* for their group activities, while the students in the control section didn't use *PeerSpace*.

To help students learn the tools provided in *Peerspace*, the students in the experiment section were required to work on 3 mini-labs. In the first lab, the students created their profile pages, wrote blogs commenting on news articles about the current technologies in the field of Computer Science, and posted or commented on discussion forum posts. In the second lab, the students get familiarized with other members of their study group by sharing their outside class interests in the group discussion forum. In addition, each group jointly created a fictional story using the group wiki tool. In the third lab, the students practiced online peer-to-peer chat, and group chat using the "virtual" group chat rooms. They also learn to subscribe to RSS feeds from *PeerSpace* announcements, forum discussions and group discussions.

Throughout the semester, the students in both sections work with his/her study group members on group assignments to design computer programs collectively, or come up with a group solution to homework. The group assignments were given weekly. The students in the experiment section have full access to *Peerspace* so that group members can collaborate with each other synchronously or asynchronously. The students in the control section mainly did pencil and pen, face-to-face collaboration. Due to physical constraints and the busy and varying schedule of all the students, the control group of students had a significantly lesser amount of time working together on these projects.

Some of the *PeerSpace* student activities are not monitored and measured directly, for example, the number of times a student initiates online chat with others in their group, or the length of the chat. Other activities are monitored and measured, for example the number of contributions each student makes in the *PeerSpace* community in terms of the number of forum discussions, blogs, and comments posted. By mid term in Fall 2010 semester, the number of posts generated by the experiment group students range from 1 to 27, with a mean and standard deviation of 9 and 6 respectively.

To measure the students' perceptions as a member of the *PeerSpace* learning community, questionnaire developed based on (Carron, Widmeyer & Brawley, 1985) and (Rovai, 2002) has been used in this study. Questions from (Carron, Widmeyer & Brawley, 1985) have been slightly reformulated to make it better suited for an academic environment and more geared towards group activities for CS students. All the questions are Likert scaled questions with a value 1 representing "strongly agree", and 5 representing "strongly disagree".

The two-tailed sample t-test was performed comparing the mean values between the experiment and the control group responses to all 38 questions. The mean response values of all the 38 questions from the experiment group all show a positive or neutral trend. T-test reveals that the mean values of student responses along six questions are statistically significant, with a ρ value less than 0.1. These six questions are:

Q1. I feel that students in this class care about each other.

Q2. I feel connected to others in this class.

Q3. I trust the others in this class.

Q4. I feel that other students do not help me learn.

Q5. Class members help one another.

Q6. Class members rarely interact with another.

Table 1 shows the t-test statistics of the student responses from the experiment and the control groups along these six questions. These results show that, compared to the control group of students, the students in the experiment group have a much closer relationship with fellow students in the class. They are much more trusting of each other, caring of each other, and much more willing to help the others in the class and collaborate on course work.

Table 1: Two-tailed T-test statistics on the experiment and control sections.

	Questions					
Mean (Std. Dev.)	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Experiment Section	2.39(0.94)	2.52(0.79)	2.26(0.86)	3.9(0.82)	1.739(0.86)	4.04(0.82)
Control Section	3.1(1.25)	3.2(0.89)	2.9(1.2)	3.3(1.34)	2.3(1.2)	3.5(1.05)
T-Test ρ value	0.045	0.012	0.057	0.067	0.087	0.07

Table 2: Test results on the experiment and control sections.

	Tests	
Mean (Std. Dev., Sample size)	**Test 1**	**Test 2**
Experiment Section	74.2 (16.3, 27)	75.4 (17.8, 26)
Control Section	70.8 (25, 23)	70.7 (24.8, 19)
T-Test ρ value	0.29	0.45

The other aspect of the evaluation focuses on assessing the effectiveness of the *PeerSpace* learning community in motivating the students to learn course materials. The question of interest is: do more collaborative learning activities lead to better learning of course materials, as measured by the test scores? Table 2 shows the results and statistics data of two tests given in the semester. It is seen that the experiment section was able to obtain a higher mean test score than the control section on both tests. Even though the two-tailed sample t-test values, 0.29 and 0.45, indicate the observed higher mean test scores are not statistically significant with ρ=0.1, the instructor of the two sections reported a better overall learning motivation and attitude from the students in the experiment section. More experiments and studies are needed to capture the differences in learning outcome attributed to *PeerSpace*.

Conclusions

Entry-level Computer Science courses currently suffer from unacceptably high dropout and failure rates. The stereotype image of the computer science student working away on a computer, alone in isolation, is pervasive. This unfortunate perception leads to less motivation for the students and less willingness to support and help fellow students and to work collaboratively that in turn worsens the study environment. The work presented in this paper attempts to change this stereotype study environment by building an integrated online collaborative learning community. Far from being isolated, the students are encouraged to involve in social interactions with fellow students, exchange ideas, help each other on understanding course materials, and engage collaboratively on course work. To facilitate online social interaction and collaborative work, a suite of web tools have been adapted and developed in this community. Initial experiments with students enrolled in the Fall 2010 semester have shown promising results where the students show a stronger attachment to their fellow students, more willingness to help and work with others in the same class, as well as an overall improved learning performance.

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