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Social Networks among Students, Peer TAs, and Instructors and Their Impacts on Student Learning in the Blended Environment: A Model Development and Testing

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Abstract:

Due to its flexibility and effectiveness, blended learning has become popular in higher education. Previous studies have discussed and presented various methods and cases that one can use and leverage in blended courses. Other studies have described and examined the technology and/or systems that support blended learning. However, no research has examined student learning from the social network perspective. Compared with traditional face-to-face instruction, blended learning incorporates a great portion of online activities. Thus, blended learning typically features fewer interactions among students, teaching assistants (if any), and instructors. Therefore, we need to examine whether and how (if any) social networks among students, peer teaching assistants, and instructors could influence student learning in the blended environment. To do so, we developed and tested a research model with a large sample size of 699 students who took a blended class. The results indicated that all three types of networks (including student-student networks, student-peer TA networks, and student-instructor networks) significantly influenced both social presence and interaction, which, in turn, had significant impacts on learning climate and perceived academic performance.

Keywords: Student-student Networks, Student-peer TA Networks, Student-instructor Networks, Learning Climate, Perceived Academic Performance.

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1 Introduction

Blended learning refers to a teaching style that adopts both traditional classroom and online education instructional methods (Hung & Chou, 2015; Padilla-Meléndez, Aguila-Obra, & Garrido-Moreno, 2013). The advancement and availability of contemporary information and Internet technology have enabled many institutions to adopt blended learning. As opposed to e-learning, which occurs purely online, blended learning allows students to meet their instructors and classmates in person such as what happens in traditional classrooms (Ahmed, 2010; So & Brush, 2008). Further, it also gives students the chance to conduct part of their learning activities online so that they may work at their own pace and on their own schedule, which makes their learning process more flexible and personal. Educators acknowledge blended learning as the third wave of change in education (after face-to-face instruction and e-learning) (So & Brush, 2008). In addition to its flexibility, blended learning has gained in attractiveness among faculty and students over years because it allows students to advance further and provides more effective instruction compared with either traditional instruction or e-learning (Padilla-Meléndez, Aguila-Obra, & Garrido-Moreno, 2013; So & Brush, 2008). By embracing a variety of teaching methods from both face-to-face instruction and e-learning, blended learning combines the advantages and overcomes the drawbacks of the other two instructional methodologies. The “offline” part of blended learning enables students to physically meet their instructors and other classmates to gain deeper insights about a subject and to learn and conduct critical thinking activities together in a richer communication channel to reinforce what they learn. This offline part can also help reduce the degree to which students feel separation that may occur with a purely online, e-learning environment. Meanwhile, the “online” part of blended learning enables students to use advanced Internet technology to assist their learning. Educators have created and used many innovative and vivid ways to present learning materials (such as user interactive e-textbooks) and assess student learning outcomes (such as online quizzes and projects) with the help of contemporary Internet technology.

A blended class needs to have two parts: online and offline class activities. However, to the best of our knowledge, we lack any specific rules about what percent of offline and online a blended class should have. Based on the nature of the class and the teaching and learning needs, different blended courses may have different emphases: some may focus more on the online activities, while others may incorporate more in-class activities.

We can group existing research on blending learning into two primary groups: research that describes and demonstrates effective course designs (Alrushiedat & Olfman, 2014; Djenic, Krneta, & Mitic, 2011; Hoic-Bozic, Mornar, & Boticki, 2009) and research that discusses the development, assessment, and/or adoption of learning management systems and other related technology that blended classes use to better support students’ online activities (Khan, 2014; Lin & Wang, 2012; Padilla-Meléndez et al., 2013; Shen, Wang, Gao, Novak, & Tang, 2009). For example, Hoic-Bozic et al. (2009) describe a blended learning course design that combined methods from collaborative learning and problem-based learning. The course included detailed teaching methods such as face-to-face and online lectures, online tests, students’ seminar papers, online discussions, and group projects. The authors conducted a survey to investigate the effectiveness of their course design and found that students were satisfied with it. In another study, Padilla-Meléndez et al. (2013) examined the impact of a learning management system, Moodle, on student learning in the blended environment. One can use Moodle to support Internet-based courses with three groups of elements called activity, resource, and block. Based on the technology acceptance model (Davis, 1989), they found that perceived playfulness significantly influenced perceived usefulness and perceived ease of use of the system, which, in turn, influenced attitude and student intention to use the system.

Although many consider blended learning to be more advanced compared with either face-to-face instruction or e-learning and to provide students with more flexibility in their learning process, one can expect that students could less frequently interact with other classmates, peer teaching assistants (TAs) if any, and instructors in a blended learning environment compared to a traditional classroom. As such, students may feel less engaged and somewhat separated, especially when conducting online activities by themselves. Therefore, we need to examine whether and how social networks (if any) among students, peer TAs, and instructors could influence student learning in the blended environment. However, we could find no research effort in this area in the existing literature. To address this gap, we empirically investigated the impacts of different types of social networks (including student-student networks, student-peer TA networks, and student-instructor networks) on student learning in the blended environment.

Specifically, we developed and tested a research model with a relatively large sample size of 699 students who took a blended class. The results showed that all three types of networks significantly influenced both social presence and interaction, which, in turn, had significant impacts on learning climate and perceived academic performance. Our findings contribute to existing research on blended learning and provide some insights to education in general.

The remainder of this paper proceeds follows: in Section 2, we discuss the related literature and develop our hypotheses. In Section 3, we detail the research method we followed. In Section 4, we analyze the data and report our results. Finally, in Section 5, we conclude the paper by discussing the study's research contributions and implications, and we discuss future research directions.

2 Literature Review and Hypothesis Development

2.1 Existing Research on Blended Learning

As an instructional method recently introduced in higher education, blended learning combines the advantages of both traditional face-to-face instruction and e-learning. Recently, it has become popular in higher education and attracted more and more attention among educators and researchers. The existing blended learning research focuses on two major perspectives: describing and demonstrating class designs and various activities in blended classes (Asoodar, Marandi, Atai, & Vaezi, 2014; Basogain, Olabe, Olabe, & Rico, 2017; Djenic et al., 2011; Hoic-Bozic et al., 2009) or discussing the development, assessment, and/or adoption of learning management systems and any other technology that blended classes use to support the online portion of class activities (Khan, 2014; Padilla-Meléndez et al., 2013; Shen et al., 2009).

Studies that focus on describing and demonstrating blended class designs have demonstrated and reported that such classes use various components, activities, and methods. For example, in a recent study, Basogain et al. (2017) systematically presented the design of two blended classes with detailed information about the course content, assessment tools, and supporting technology and systems. Adopting the blended course structure, each class's instructor facilitated each class in the classroom setting and online learning platforms. Specifically, both courses taught students the introductory concepts and processes in computational thinking, but the second also taught advanced topics and included more challenges in its course materials. Both courses used Alice as the programing environment to allow students to create object-oriented functions and procedures. Further, both courses used a variety of teaching methods such as video lessons (i.e., video tutorials about course subjects), interactive quizzes (i.e., online tests based on multiple choice questions of concepts), peer-to-peer projects, and online forum discussions (Basogain et al., 2017). In another study, Hoic-Bozic et al. (2009) discussed how they designed and implemented a blended course on teaching methods in information science in detail. Three learning paradigms (i.e., cognitivism, behaviorism, and constructivism) inspired the course design, which also emphasized problem-based learning and group work. Specifically, the researchers first conducted a two-hour face-to-face lecture on the class's first two topics after which students learnt the remaining topics online. A majority of the class activities occurred online, including online presentations and tests, students' seminar papers, online discussions, a students' group project, and courseware reflection via a written summary (Hoic-Bozic et al., 2009). When teaching programming courses, Djenic et al. (2011) demonstrated a blended course design for teaching object-oriented languages, such as C++. The course provided students certain face-to-face learning activities, including classroom learning, practice in computer labs, and reading printed textbooks. In addition, the class also provided and used online resources and activities in the class, such as the interactive CD editions of textbooks, online lecture slides, online exercises and quizzes, forum discussions, and online interactive simulations and applications for problem solving (Djenic et al., 2011).

Since online activities and resources typically form an important portion in blended classes, an existing research stream focuses on discussing the development, assessment, and/or adoption of the supporting technology and systems that blended classes use. Technology and Internet-based learning management systems that can support students' online activities in the blended classes in an effective and efficient manner determines in large part whether blended learning succeeds. For example, Khan (2014) discussed in detail how she implemented a learning management system to help business students learn computer applications in blended classes and how students actually adopted it. The author summarizes issues that non-IT students face when learning information technology and presents a learning management system that she developed to better engage students in the blended learning environment and attract their attention. The system incorporated tools of online lectures, videos tutorials, online discussions, online quizzes, and forums. The author assessed and improved the system's functions through a three-stage development process and observed that students failed at a significantly lower rate after each improvement (reduced from 14% to 6%). Overall, Khan (2014) found the system to be a very effective tool in teaching business students computer applications in the blended classes. In another study, Padilla-Meléndez et al. (2013) examined the adoption of a blended learning system (i.e., an Internet-based learning management system that supports the online activities in a blended class). Specifically, the author assessed Moodle—a popular platform that one can use to support Internet-based courses with three groups of elements called activities (such as online assignments, chat, forum, quizzes, wiki, etc.), resources (such as online files and URLs), and blocks (such as calendars, comments, course completion status, social activities, upcoming events, YouTube, etc.). Based on the technology acceptance model (Davis, 1989), the authors found that perceived playfulness significantly influenced perceived usefulness and perceived ease of use of the system, which, in turn, influenced attitude and student intention to use the system. The authors also observed gender differences in system adoption. Specifically, they found that perceived playfulness had a direct impact on female students' attitude about system use; however, perceived usefulness mediated that impact for their male counterparts (Padilla-Meléndez et al., 2013). Because mobile devices have become popular among college students, Shen et al. (2009) studied the development and adoption of a mobile learning system to support student learning in blended classes. The system enabled the instructor to set up a multimedia classroom from the instructor's station. While teaching, the instructor could use PowerPoint slides or handwriting on the screen, and the system captured, recorded, and broadcasted live video to students. The system also enabled students to interact in real time with the instructor by delivering their questions and feedback as mobile phone text messages. To use the system, a student could choose from three modes: a real-time classroom view (for online students), a virtual student view (for offline students), and a front row view (that allows students to see the instructor's facial expressions and other body language). Overall, the authors found that students were satisfied with the blended class that this mobile learning system assisted.

2.2 Social Networks

As we discuss above, although existing studies have focused on either demonstrating the class designs and instructional methods that blended classes use or discussing the development, assessment, and/or adoption of the advanced systems and any other technologies that educators use to support the online portion of blended classes, few studies have examined blended learning from the social network perspective. In particular, few have examined the impact that interactions among students, peer TAs, and instructors have on student learning in the blended environment. In this study, we address this gap.

We believe that examining blended learning from the social network perspective can provide insight into our understanding on student engagement since blended learning typically involves a significant portion of online activities. On one hand, it gives students more flexibility and potentially leads to a higher level of interest in their learning. However, on the other hand, students in a blended class could interact less frequently with other classmates, peer TAs (if any), and instructors than in a traditional classroom. Thus, we need to investigate and understand whether and how social networks (if any) among students, peer TAs, and instructors could influence student learning in a blended environment.

Social network theory (Chen, Yeh, Lou, & Lin, 2013; Cheng, 2011; Scott, 2000) investigates how individuals' ties with others in a given context could influence outcomes of interest. A social network refers to a social structure with nodes (generally individuals) and links that indicate the ways nodes connect to one another. Researchers create social networks based on the context of the relationships they model. Researchers have applied social network theory to study interesting and important phenomenon in different contexts, such as consumer interactions in online blogs (Chau & Xu, 2012), collaboration among researchers in the information systems (IS) area (Xu, Chau, & Tan, 2014), the adoption of computers in rural areas (Venkatesh & Sykes, 2012), and employees' job performance (Zhang & Venkatesh, 2013). For example, Chau and Xu (2012) conducted a social network analysis to understand blogger interactions in online communities. Specifically, they proposed an analysis framework to gather business intelligence from online blogs. To demonstrate the framework, they conducted two case studies on blogs (one related to the iPad and one to Starbucks). For each case study, the authors conducted a detailed social network analysis and reported the results on content analysis, interaction networks, central bloggers, and implicit communities. In another study, Xu et al. (2014) applied the social network theory to examine the network ties, network configuration, structural holes, growth, and structural cohesion about the collaboration among researchers in the IS area. Specifically, they created the co-authorship networks based on publications from six leading IS journals over 33 years. They also reported detailed network patterns in their paper.

When studying systems adoption, Venkatesh and Sykes (2012) developed a model to examine the digital divide in developing countries from the social network perspective. Specifically, they examined the impacts of two social network constructs (i.e., eigenvector centrality and closeness centrality) on technology use and economic outcomes in rural areas in India. Eigenvector centrality measures the extent to which an individual is linked to influential others, and closeness centrality measures how close an individual is to every other individual in the network. Data analysis results showed that both eigenvector centrality and closeness centrality had a significant impact on technology use and economic outcomes. In another study, Zhang and Venkatesh (2013) used social network as the theoretical lens to examine employees' job performance. Particularly, they looked into two different types of ties among employees: direct and indirect ties. They assumed a direct tie to exist if two employees communicated with each other directly and an indirect tie if they did not communicate with each other directly but had links between them via the connection of some other employees in the middle. As to the workplace communication, they examined both the online (where people interact with each other virtually using various online communication technologies) and offline (i.e., face-to-face communication) ones. Overall, they found that online direct, online indirect, and offline direct ties were significantly related to job performance.

Other studies have created different types of social networks to investigate interesting patterns of social interactions among different roles. For example, when studying players' interactions in the settings of three dimensional (3D)-based massively multiplayer online games (MMOGs), Keegan, Ahmad, Srivastava, Williams, and Contractor (2010) created and examined trade networks among gold farmers and non-gold farmers using the social network measures of in-degree, out-degree, and centrality. In particular, they examined these networks in the Sony Online Entertainment (SOE) game EverQuest II. Gold farming refers to the practices that online game players conduct to obtain and sell in-game resources and virtual goods for real-world money. SOE did not approve these behaviors. Gold farmers refer to those game players who conduct gold farming. In-degree and out-degree measures the number of incoming and outgoing directed ties for a given node in the network. For example, a node with a high in-degree level means that it has many incoming links. Centrality (including closeness, betweenness, and eigenvector centrality) refers to series of measures that one can use assess how "important" or "prominent" a node is based on its position in the network. They found that gold farmers had significantly lower in-degrees and out-degrees compared with non-gold farmers, which indicates that gold farmers typically tended to conduct transactions with only a few trusted game players. In addition, Varvello and Voelker (2010) developed "human-to-human" and "human-to-bot" interaction networks to study social interactions in Second Life, one of the most popular 3D virtual worlds in which users can interact with one another via avatars. In the study, the authors defined a bot as an avatar-like object used to collect data from real avatars around it. They found significant differences between the two types of networks in terms of degree, clustering coefficient, and betweenness centrality. Specifically, they found "human-to-bot" interaction networks to have much higher degrees and betweenness centrality scores compared with the "human-to-human" networks. In a more recent study on Second Life, Zhang, Dang, Brown, and Chen (2017) created two groups of networks: one based on avatars' gender and one on their age. For gender, the authors developed three types of networks: male-male networks, female-female networks, and mixed gender networks. Similarly, they formed three types of networks for age: old-old networks, young-young networks, and mixed age networks. Overall, they found that the interaction networks of the same gender tended to be more centralized than the interaction networks with mixed genders, and they found similar patterns with age. When studying systems adoption, Sykes, Venkatesh, and Johnson (2014) examined the post-implementation success and employee job performance on enterprise systems by looking into the advice networks. Based on two dimensions of advice (i.e., workflow vs. software and getting vs. giving advice), they created different types of advice networks, such as get-advice networks on workflow, get-advice networks on software, give-advice networks on workflow, and give-advice networks on software. They found networks to be positively associated with employees' job performance in the post adoption of enterprise systems.

Inspired by the research we mention above, we identified three types of social networks based on the interaction patterns that occur in blended classes: student-student networks, student-peer TA networks, and student-instructor networks.

2.3 Social Presence

Researchers have widely used social presence theory (Short, Williams, & Christie, 1976) to assess media choice from a social influence point of view. It measures communication media based on the degree of awareness of others in a communication interaction and states that a fit between the social presence that a medium provides and the social presence needed to convey a message can lead to effective communication (Short et al., 1976). In general, a communication medium with higher social presence can help achieve message senders and recipients better understand one another. Adding or removing certain communication modalities such as verbal and non-verbal cues and immediately exchanging feedback can change the social presence level of a communication medium (Sallnas, Rassmus-Grohn, & Sjostrom, 2000). Researchers consider face-to-face communication to have the most social presence and text-based communication the least. As for education, researchers generally believe the traditional classroom setting to have a higher degree of social presence compared to e-learning (Johnson, Hornik, & Salas, 2008).

The theoretical construct of social presence refers to the degree to which individuals perceive the salience of others in their interactions with them and across their interpersonal relationships (Johnson et al., 2008; Richardson, Maeda, Lv, & Caskurlu, 2017). In technology-based communications, one can use social presence to assess how people represent themselves in a given technology-enabled medium (Kehrwald, 2008). For example, a user's ID can represent a user in a Web forum, while an avatar may represent a person in a virtual world. In the context of technology-supported education, researchers have argued that social presence represents an important factor to consider when determining a learning environment's effectiveness (Johnson et al., 2008; Kim, Song, & Luo, 2016; Richardson et al., 2017; Weidlich & Bastiaens, 2017). Although e-learning's major limitation concerns students' inability to directly interact with their instructors face-to-face, educators have adopted advanced learning management systems to deal with this issue by providing features that students can use to interact with each other and with their instructors, such as discussion boards, chats, and messages. By doing so, one can create a social context that leads students to perceive a certain level of social presence (Johnson et al., 2008).

Blended learning combines the instructional methods that both traditional classrooms and online education use. Students still have the opportunity to meet and interact with each other, their instructors, and peer TAs (if any) face to face, which can help assure the existence of a considerable level of perception on social presence. Meanwhile, they also can conduct online activities individually or collaboratively and virtually interact with others to share information or seek help. Thus, we can expect that their interactions through the three types of networks (i.e., student-student networks, student-peer TA networks, and student-instructor networks) will help students to feel more socially connected with their classmates, TAs, and instructors and, thus, to believe that an adequate level of social presence exists. A peer TA typically refers to a fellow student who has taken the course and received training to assist students with their lab projects and other activities, while an instructor leads the progress of the whole class, teaches students the most important and challenging course topics, and provides them the information, insights, and guidance they need. Due to the social support that students receive in a blended class via the three types of networks, we believe that the three types of networks can positively influence their perceptions about social presence. Therefore, we propose:

H1: Student-student networks positively influence students' perceptions about social presence in a blended class.

H2: Student-peer TA networks positively influence students' perceptions about social presence in a blended class.

H3: Student-instructor networks positively influence students' perceptions about social presence in a blended class.

2.4 Interaction

In an education context, the theoretical construct interaction (also called "perceived interaction" or "social interaction") refers to the exchange of information between various roles involved in the learning process, which includes students, instructors, and any other supportive personnel (such as peer TAs) (Johnson et al., 2008). Many studies have reported that interaction represents an important factor to consider in technology-supported learning (Chen, 2014; Kurucay & Inan, 2017; Sun, Tsai, Finger, Chen, & Yeh, 2008; Wu, Tennyson, & Hsi, 2010). For example, researchers have found that a learner with a higher level of perception of interaction with others in a e-learning or blended learning environment will be more likely to be satisfied with the class (Sun et al., 2008) and to have a better course performance (Johnson et al., 2008; Wu et al., 2010). Researchers believe that the interaction that occurs among students, TAs, and their instructors can help students to construct new knowledge and improve their self-regulatory skills, which positively contributes to their personal development (Kurucay & Inan, 2017).

Researchers have argued that providing enough interaction support in blended classes is important to meet students' learning needs (Sun et al., 2008). Thus, the activities conducted among students, peer TAs, and instructors (both online and in classroom) via the three types of networks could potentially play important roles in influencing students' learning in blended classes. Therefore, we hypothesize:

H4: Student-student networks positively influence interaction in a blended class.

H5: Student-peer TA networks positively influence interaction in a blended class.

H6: Student-instructor networks positively influence interaction in a blended class.

2.5 Learning Climate

The theoretical construct learning climate refers to the learning atmosphere that surrounds learners (Chen, 2014; Wu et al., 2010). To claim an instructional design as effective, one needs to consider the learning climate (Wu et al., 2010) since students who perceive a class to have a favorable and pleasant learning environment are more likely to be motivated to learn, have a positive attitude, and actively participate in the learning process.

Social presence concerns an individual's ability to perceive others in a technology-supported learning environment. A higher level of perception about others who can influence one's learning in a blended class (such as one's classmates, TAs, and instructors) can help make one feel a higher level of involvement and engagement. Such a positive impression could then lead to a positive perception about the environment that the blended class provides. Therefore, we would expect social presence to have a positive impact on learning climate. In addition, previous studies have examined what impact interaction has on learning climate and found that interaction significantly influenced learning climate in different contexts of technology-supported learning, such as in a blended class that used an e-learning system (Wu et al., 2010) and a Web-based English learning environment (Chen, 2014). Thus, we hypothesize:

H7: Social presence positively influences learning climate in a blended class.

H8: Interaction positively influences learning climate in a blended class.

2.6 Perceived Academic Performance

An important dependent variable that researchers have used to examine the degree to which an instructional design succeeds, perceived academic performance refers to learners' perception about their achieved academic performance (Islam, 2013). Researchers generally agree that education should ultimately focus on teaching students to digest, understand, and gain the knowledge they need to know and that may benefit them later in their professional life. As such, academic performance represents an important measure for the degree to which students succeed in their education.

Previous research on technology-supported learning has investigated factors that relate to students' perceived academic performance and ways that can positively contribute to it. In general, research has found that, if a student likes and enjoys a class, the student is more likely to have a higher level of perceived academic performance (Lee & Lee, 2008). In addition, studies also found that higher levels of interaction (Johnson et al., 2008; Sun et al., 2008) and social presence (Johnson et al., 2008) can lead to a higher level of satisfaction in technology-supported learning. Therefore, we can expect that positive perceptions on interaction and social presence can result in a high level of perceived academic performance. Thus, we hypothesize:

H9: Social presence positively influences perceived academic performance in the blended class.

H10: Interaction positively influences perceived academic performance in the blended class.

Figure 1 summarizes our proposed research model with the above listed ten hypotheses.

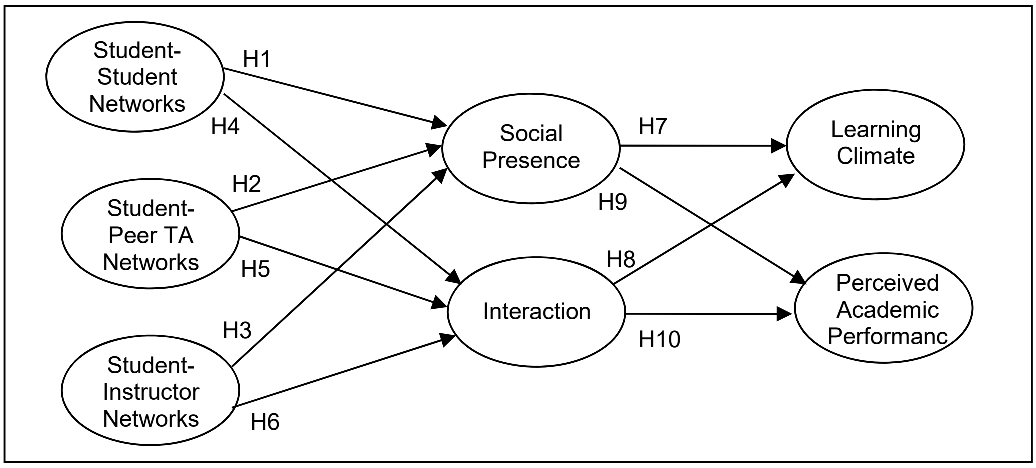

Figure 1. Research Model and Hypotheses

3 Research Method

3.1 Research Process and Data Collection

To test the proposed research model and hypotheses, we used the survey method with a lower-level introduction to computer information systems class at a major public university in the western part of the United States that students across different colleges of the university had to take. The class taught around a 1,000 students each semester with multiple, coordinated sections. The class employed the blended learning instructional method to better support the large number of students with different backgrounds and increase student success rates. The class used both offline and online components. Specifically, it had a face-to-face weekly class meeting where faculty, peer TAs, and students interacted and discussed the week's assigned topics and current events. For the online component, the class employed an online textbook, online assessment software, and an online learning management system. The online component allowed students to work independently, outside of class time, at their own pace, and on their own schedule.

The class adopted some detailed teaching methods and activities to assist student learning. The online part of the class used a digital textbook, which included embedded YouTube videos that related to the content on each reading. It also contained a section with video tutorials that walked users through the Microsoft Office skills (e.g., Word, Excel, PowerPoint, and Access). Students needed to watch and follow the video tutorials to complete the projects by themselves. In addition, the course used an online learning management system where students could find all course-related materials and links. Students had access to all individual quizzes, assignments, and projects in the system from the first day of class so they could work ahead. To further assist students in learning Microsoft Office skills, the course also used online assessment software for students to complete additional projects for each application in the Microsoft Office package.

For the offline part, the class met in a regular classroom once a week, which provided students with additional opportunities to interact with their instructors and, thus, to better understand the course materials and to conduct critical thinking-based group activities with other classmates. Specifically, students and instructors could discuss and debate current events that relate to the week's topic. Where online videos from YouTube or news sources were available, the instructor used these multimedia sources to generate discussion and relate the conceptual readings to the events. Then, students needed to work in small groups of four to five people to work on a project that focused on extending what they gathered before class time and applying it to a new situation. Each student group worked on a different topic, and, after a short while, the groups presented their analysis or findings to the class so everyone benefitted from their efforts. In the remaining few minutes at the end of class, students finished working with their small group by completing a ten-question quiz related to the chapter topic. This activity provided one last opportunity for students to discuss the concepts from the week's readings and earn class points together with their team members.

Students, peer TAs, and instructors interacted closely in the learning process. For example, students worked as part of a group of four to complete weekly in-class activities and group quizzes. Peer TAs supervised these groups and assisted them in completing the in-class tasks. The instructor interacted with the student groups each week as they completed their activity and quiz assignments. Further, faculty members engaged in regular, weekly email communication with students to convey information about assignments, grades, and operational aspects of the course, and they held regular office hours for students to come by for individual and personalized assistance.

Additionally, students could access peer TAs and instructors in the open technology lounge (referred to as the "tech lounge"), a computer lab that only students in this course could use from Monday to Friday. If students required assistance with out-of-class online assignments or projects, they could drop in to get assistance. TAs and instructors took shifts to cover the lab time. They provided help to students who were both in and not in their own classes. Students who took the course did not physically have to use the tech lounge to work on their assignments and projects, but the instructors and TAs encouraged them to get help there whenever they needed it.

We sent the survey invitation to students who enrolled in the class[1] a few weeks before the end of the semester. We provided extra credit (1% of total course points) as an incentive for students' voluntary participation. When participants agreed to participate, we sent them a set of questionnaire instruments related to the constructs in the research model. In total, 699 students completed the survey (297 males and 402 females). On average, the participants were 19.6 years old and had been at university for 1.8 years (the sample contained 317 first-year students, 224 second-year students, and 158 third- and fourth-year students).

3.2 Measures of Constructs in the Research Model

To develop the measurement items for the three types of networks (i.e., student-student, student-peer TA, and student-instructor networks), we followed the general method that Sykes et al. (2014) used to measure advice networks among employees and created detailed measurement items to fit the context of blended learning. We adapted the measurement items of social presence from Johnson et al. (2008) with minor changes to ensure they fit a blended learning context. We adapted the measurement items about interaction and learning climate from Chen (2014) and partially adapted items on perceived academic performance from Islam (2013) with changes to ensure they better fit the context of this study. We measured all constructs in the research model using a seven-point Likert scale. Appendix A describes the measurement items in detail.

4 Data Analyses and Results

We used structural equation modeling (SEM) techniques to assess the research model. In particular, we used a widely used and robust method for causal model assessment, component-based SEM (PLS) (Chin, Diehl, & Norman, 1988; Chin, 1998). In this study, we used Smart PLS 2.0 (M3) beta, a widely adopted PLS tool for causal model analysis. Because students rated the measurement items for each latent construct, we obtained perceptions as our findings in this study. In Sections 4.1 and 4.2, we present the data analysis and results for both the measurement model and structural model (hypothesis testing).

4.1 Measurement Model Assessment

We conducted reliability and validity tests for the latent constructs in the research model. Table 1 shows the reliability test results. All item loadings were greater than the threshold value 0.7 (Au, Ngai, & Cheng, 2008) and statistically significant. In addition, the Cronbach's alpha values for all constructs were greater than the 0.7 guideline (Hair, Anderson, Tatham, & Black, 1998; Nunnally, 1978).

Table 2 shows the composite reliability, average variance extracted (AVE), square root of AVE, and correlations among constructs. The composite reliability values of all constructs were above the recommended level 0.70, which indicates adequate internal consistency between items (Au et al., 2008).

[1] Various university departments required students to complete the class. We acknowledge that information about the breakdown of the diversity for students from the whole university and the descriptive statistics on the distribution of respondents in terms of major, cross tabulation of major and gender, and residential vs. part-time would prove useful. However, we did not collect such data when conducting the survey. However, we did collect data about the descriptive statistics of the participants in terms of their gender and years of school, which we summarize in this paragraph.

Our model also demonstrated convergent validity because the AVE values for all constructs were higher than the suggested threshold value 0.50 (Gefen, Straub, & Boudreau, 2000). Comparing the square root of AVE with the correlations among the constructs indicates that each construct was more closely related to its own measures than to other constructs' measures, which supports discriminant validity (Chin et al., 1988; Chin, 1998).

Table 1. Reliability Test Results

Construct	Cronbach's alpha	Item	Loading	T-statistics
Student-student networks (SSN)	0.903	SSN1	0.876	66.484
		SSN2	0.930	147.035
		SSN3	0.937	200.149
Student-peer TA networks (SPN)	0.918	SPN1	0.937	157.746
		SPN2	0.920	95.077
		SPN3	0.924	119.733
Student-instructor networks (SIN)	0.905	SIN1	0.819	45.404
		SIN2	0.932	145.536
		SIN3	0.887	66.636
		SIN4	0.887	87.527
Social presence (SP)	0.834	SP1	0.729	29.876
		SP2	0.819	54.774
		SP3	0.757	30.461
		SP4	0.796	41.333
		SP5	0.772	31.273
Interaction (I)	0.914	I1	0.872	73.220
		I2	0.920	126.362
		I3	0.882	76.540
		I4	0.894	105.867
Learning climate (LC)	0.946	LC1	0.914	122.574
		LC2	0.948	206.218
		LC3	0.948	192.128
		LC4	0.898	89.978
Perceived academic performance (PAP)	0.873	PAP1	0.892	76.788
		PAP2	0.859	68.084
		PAP3	0.925	105.460

Table 2. Internal Consistency and Validity Test Result

Construct	Composite reliability	AVE	PAP	I	LC	SP	SIN	SPN	SSN
PAP	0.921	0.796	**0.892**						
I	0.940	0.796	0.504	**0.892**					
LC	0.961	0.860	0.620	0.799	**0.927**				
SP	0.883	0.601	0.431	0.615	0.618	**0.775**			
SIN	0.933	0.779	0.472	0.549	0.576	0.417	**0.883**		
SPN	0.948	0.859	0.382	0.519	0.521	0.306	0.563	**0.927**	
SSN	0.939	0.837	0.373	0.654	0.598	0.395	0.590	0.611	**0.915**

Note: diagonal elements in bold case are the square root of average variance extracted (AVE) by latent constructs from their indicators; off-diagonal elements are correlations among constructs.

4.2 Structural Model Assessment

Figure 2 shows the PLS test results of the research model. As hypothesized, both student-student networks and student-instructor networks significantly influenced students' perceptions about social presence with path coefficients of 0.223 and 0.277, respectively. Therefore, we found support for H1 and H3. However, the impact of student-peer TA networks on social presence (i.e., H2) was not significant, which may indicate that, during students' learning process in a blended class, their connections with other classmates and their instructors may increase their feeling of being connected in the class but that their connections with peer TAs does not significantly contribute to such a perception. Together, the two significant factors student-student networks and student-instructor networks explained 20.8 percent of the variance of social presence.

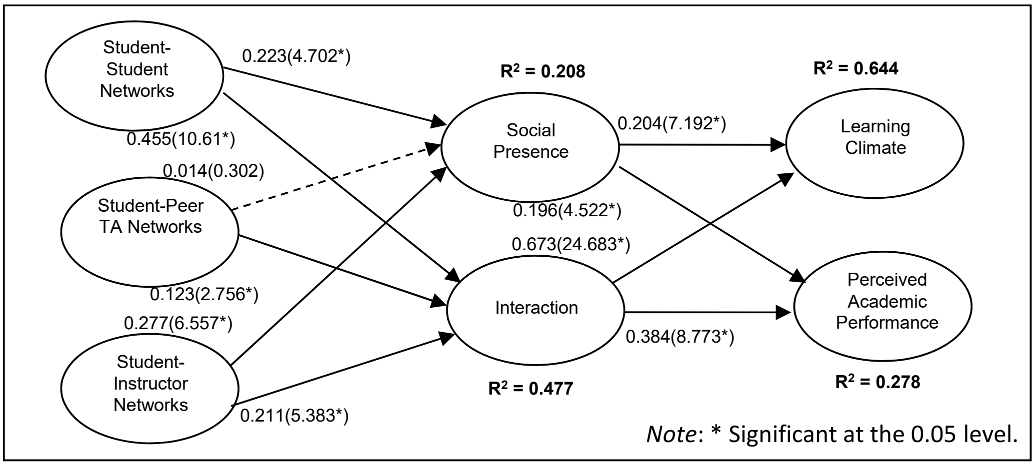

Figure 2. Model Test Results

Further, the three types of networks had a statistically significant impact on interaction with path coefficients of 0.455, 0.123, and 0.211 for the student-student network, student-peer TA network, and student-instructor network, respectively. Therefore, we found support for H4, H5, and H6. These three types of networks together explained 47.7 percent of the variance of interaction.

In addition, we found that both social presence and interaction significantly influenced learning climate with path coefficients of 0.204 and 0.673, respectively. Thus, we found support for both H7 and H8. The R-squared value indicates that social presence and interaction together explained 64.4 percent of the variance of learning climate. Similarly, we found that both social presence and interaction had a significant impact on students' perceived academic performance with the path coefficients 0.196 and 0.384, respectively. Social presence and interaction together explained 27.8 percent of the variance of perceived academic performance.

5 Discussion

In order to combine the advantages from both traditional, face-to-face instruction and e-learning, blended learning has become popular in contemporary higher education. With this study, we make several contributions to the existing blended learning research. First, we examine the blended learning environment from a social network perspective, which previous studies have scarcely done. As we discuss in Section 2, the majority of existing research on blended learning has focused on either presenting or demonstrating the class designs and innovative activities adopted in blended classes or discussing the development, assessment, and/or adoption of advanced online learning management systems or any other supporting technologies that blended classes use. We believe blended learning represents an important research topic since it typically involves a significant portion of online activities. On one hand, it gives students more flexibility and potentially leads to a higher level of interest in their learning with the help of contemporary information and Internet technology. However, on the other hand, students in a blended class could interact less frequently with other classmates, peer TAs (if any), and instructors than in the traditional classroom. Therefore, some students may not engage as much in such a class and feel somewhat separated from it. As such, we need to examine the interactions and social ties among different roles involved in blended learning (including students, peer TAs, and instructors), and further investigate how they can influence student learning in the blended class. This study makes contributions in this direction.

Second, by leveraging the social network theory, we identify three types of networks based on the stakeholders involved in the learning process in a blended class (including students themselves, the peer TAs, and their instructors) and investigate what impact they have on student learning. Specifically, we identify the three types of networks: student-student, student-peer TA, and student-instructor networks. We believe all contribute to a blended class's success. When conducting group activities, students need to interact with other classmates. When they need some general information or help related to the class, they may also turn into their classmates. Thus, student-student networks could play an important role in student learning in a blended class. Peer TAs assist students with some of their in-class discussion activities. In our study, they also provided help and support in the technology lounge where students could stop by (voluntarily) to seek help about their hands-on lab projects. Thus, we need to examine the impact of student-peer TA networks on student learning as well.

As for instructors, they typically lead a blended class's progress and have the responsibility to make sure that students effectively learn content in both its online and offline portions. Their communications and interactions with the students could be the most critical because they need to answer their most challenging questions, provide them with important knowledge, and offer guidance and insights related to the blended course and the topics it covers. Therefore, student-instructor networks could play an essential role in student learning in a blended class.

When designing the specific learning methods and activities for this class, we promoted interactions among students, peer TAs, and instructors. For example, during the class meeting time, students had the chance to work in groups to discuss current events, conduct analytical cases related to the topic of that week, and present their findings and results to the whole class. In addition, we also gave them the chance to complete a team quiz to further help improve their teamwork ability. During their discussions when completing the teamwork, each team could seek additional help and assistance from a peer TA, and each class typically had two to three peer TAs to cover all groups in the whole class. Meanwhile, the instructor interacted with each group by answering more critical questions, providing additional insights, and giving feedback on the findings and results the groups obtained. The tech lounge and course instructors' office hours provided students with more opportunities for personalized care and interactions. In sum, in our blended class, students benefitted from the flexibility that its online portion enabled (where they could work on the chapter readings and other related course materials and complete the individual quizzes and projects at their own pace and in their own choice of location) and engaged with the class at a sufficient enough level via interacting with other classmates, peer TAs, and instructors. Such interaction could ultimately increase students' positive attitude about the course subjects to learn and how efficiently they learn. We hope that our class design provides an example for others about how they can teach a blended class that incorporates balanced online and offline portions.

Third, in this study, we develop a theoretical research model to examine the impact that three types of networks have on student learning. Specifically, we look into how they influence students' perceptions about social presence and interaction and, in turn, how these perceptions influence learning climate and students' perceived academic performance. We also empirically tested the proposed research model and found that, in general, the three types of networks significantly influenced both social presence and interaction (except for the path from student-peer TA networks to social presence). Thus, we found that social presence and interaction had a significant impact on both learning climate and students' perceived academic performance. Overall, these results indicate the importance of students' social interactions for blended learning to succeed. To promote a positive learning climate and to improve students' expectations on their class performance, one needs to ensure that the learning environment is sociable and personal to them and that it provides enough and efficient interactions and communications to help them learn. Our findings show that all three type of networks helped student learning in general, which suggests that, when designing a blended class, educators should consider promoting strong ties between students and their classmates, peer TAs, and instructors. To do so, educators can create and incorporate innovative teaching methods and class activities (in addition to the ones we present in this study) to help encourage students to communicate more, both in-class and online, with other classmates, peer TAs, and instructors in order to provide a collaborative and interactive learning environment.

6 Future Research Suggestions

Future research can further improve this study in several directions. First, we tested our research model with students, many of whom had only recently begun attending university (e.g., first- and second-year students). Second, we examined blended learning from the social network theoretical perspective. Future research may incorporate it with other well-studied perspectives, such as technology adoption and information systems success, to create a more comprehensive view using multiple theoretical lenses. Third, future research may look into gender differences in the blended learning environment and compare students' learning in such an environment across different types of student bodies (such as international students vs. domestic students and first-generation students vs. non first-generation students). In addition, the data analysis results showed that the impact of student-peer TA networks on social presence (i.e., H2) was not significant, but we did not specifically collect data to examine the exact reasons about why. Such results might indicate the need to improve the quality and/or quantity of peer TAs. It might also suggest the need to create and adopt more class activities that specifically promote the communications between students and peer TAs. In any case, future research could consider conducting interviews on students and collecting their options about the help and assistance that their peer TAs offer in a blended class.

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Appendix A: Measurement Items

Student-student networks

SSN1: In general, I often contact or am contacted by my classmates for learning-related activities related to this blended class.

SSN2: In general, I often interact with my classmates for learning-related activities related to this blended class.

SSN3: In general, I feel connected to my classmates in the blended learning environment.

Student-peer TA networks

SPN1: In general, I often interact with my peer TAs (including peer TAs both in the class and in the lab) for learning-related activities related to the blended class.

SPN2: In general, I often seek help from my peer TAs (including peer TAs both in the class and in the lab) for learning-related activities related to the blended class.

SPN3: In general, I feel connected to my peer TAs (including peer TAs both in the class and in the lab) in the blended learning environment.

Student-instructor networks

SIN1: In general, I often contact or am contacted by my instructor for learning-related activities related to this blended class.

SIN2: In general, I often interact with my instructor for learning-related activities related to this blended class.

SIN3: In general, I often seek help from my instructor for learning-related activities related to the blended class.

SIN4: In general, I feel connected to my instructor in the blended learning environment.

Social presence

SP1: The blended learning environment is: Impersonal/Personal

SP2: The blended learning environment is: Unsociable/Sociable

SP3: The blended learning environment is: Insensitive/Sensitive

SP4: The blended learning environment is: Cold/Warm

SP5: The blended learning environment is: Passive/Active

Interaction

I1: The blended learning environment enables interactive communication between instructors and students.

I2: The blended learning environment enables interactive communication among students.

I3: The blended learning environment is a medium for social interaction.

I4: The blended learning environment offers effective communication that I need for my learning.

Learning climate

LC1: The process of using the blended learning environment to assist my learning is pleasant.

LC2: I have fun with the blended learning environment.

LC3: I find the blended learning environment to be enjoyable.

LC4: The learning climate provided by the blended learning environment could motivate my spontaneous learning.

Perceived academic performance

PAP1: I anticipate good grades in the blended class.

PAP2: I anticipate better grades in the blended class compared with other classes that have the same difficulty level but without adopting the blended learning environment.

PAP3: I anticipate that I will be satisfied with my academic performance in the blended class.

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