The Effect of Social Presence on Affective and Cognitive Learning in an International Engineering Course Taught via Distance Learning

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Background
Distance learning course formats can alter modes of information exchange and interpersonal interaction relative to traditional course formats.

Purpose (Hypothesis)
To determine the effect of a distance course format on the knowledge acquisition (cognitive learning) and satisfaction (affective learning) of students, we investigated student learning responses and social presence during a graduate-level engineering course taught via traditional (i.e., professor present in the classroom) and synchronous distance-learning formats.

Design/Method
Direct quantification of participation, academic performance assessment based on homework and exam scores, and survey-based assessments of student perceptions of the course were collected. Based on these data, cognitive and affective learning responses to different technological and interaction-based aspects of the course were determined for each course format.

Results
We show that while affective learning decreased for students in the distance format course relative to the traditional format, cognitive learning was comparable. Our results suggest that loss of satellite connection and audio losses had a stronger negative effect on student perceptions than video disturbances, and that participation was the most important factor influencing affective learning.

Conclusions
While our findings do not suggest that cognitive learning is strongly affected by social presence, implementing strategies to enhance social presence may improve the overall learning experience and make distance learning more enjoyable for students.

Keywords
distance learning, participation, social presence

I. Introduction

Distance learning has emerged in response to growing demands for educational opportunities without the spatial restrictions of traditional learning environments and has become an important tool in higher education. As of 2003, over 80 percent of all institutions of higher education (not limited to engineering) offered at least one fully online or blended course (Sloan Consortium, 2007). Moreover, online enrollment increased in the U.S. to 3.9 million students in 2007; a 12 percent increase over the number reported in 2006 (Allen and Seaman, 2008). However, engineering is the only discipline area where online representation is much lower than for other areas (Allen and Seaman, 2008), suggesting that there may be considerable room for expansion in this field. In light of these facts, the potential for distance learning to impact large groups of students is evident and the importance of evaluating distance-learning programs relative to traditional classroom-based engineering courses is apparent.

Numerous studies have investigated the differences in outcomes between distance learning and traditional instruction by comparing cognitive and affective learning. Several studies strongly indicate that there is no difference in cognitive learning between distance- and traditional-format courses (Offir and Lev, 1999; Pitcher, Davidson, and Goldfinch, 2000). Rudestam and Schoenholtz-Read (2002) show that no significant differences in academic performance trends occur between distance learning and traditional courses, even if students have expressed a preference for the latter. But despite evidence for equality in cognitive learning, affective learning, which describes the attitudes and feelings of the learner with respect to knowledge gained, is more variable in response and more challenging to quantify.

There is a clear need to develop effective pedagogical strategies that complement and maximize the benefits of new technologies in the classroom. The goal of this study was to evaluate the cognitive and affective learning responses of students during a graduate-level engineering course taught via traditional (i.e., professor present in the classroom) and synchronous distance-learning formats in order to identify aspects of the course (e.g., technological issues and interpersonal interaction) that were most important in determining student satisfaction (affective learning) and knowledge acquisition (cognitive learning). Participation, academic performance, and student perceptions of the course were assessed. We provide background information on social presence theory and specific aspects of the course, a description of the methods used to collect and interpret the data, and discussion of the results. We conclude with specific recommendations for improving distance courses.

II. Background

A. Social Presence Theory

Social presence theory provides a useful framework for understanding learning outcomes in distance courses. Short, Williams, and Christie (1976) define social presence as the "degree of salience of the other person in the interaction and the consequent salience of the interpersonal relationship." This definition essentially refers to the degree to which a person is perceived as a "real person" during communication (Gunawardena, 1995). The two fundamental concepts upon which social presence is developed are intimacy (which stems from factors such as eye contact, physical proximity, and topic of conversation) and immediacy (the psychological distance between communicating individuals as determined through speech and related communication cues) (Short, Williams, and Christie, 1976). Factors leading to immediacy include gesturing, facial expressions, using humor and personal examples, addressing students by name, initiating discussion and encouraging feedback, and avoiding tense posture (Aragon, 2003). Because intimacy and immediacy are altered by distance learning settings, social presence is also likely to be substantially affected in these settings.

The link between affective learning and social presence is well established for distance learning environments; for example, an increase in the level of social presence leads to more interaction in online classes (Tu and McIsaac, 2002) and greater satisfaction (Baker, 2004), though Garrison and Cleveland-Innes (2005) note that structure and leadership are also necessary. The mode of instruction and out-of-class communication with the instructor both influence student satisfaction (Biner et al., 1997), and Offir and Lev (1999) show that the effectiveness of distance learning is improved through increased student-instructor interaction. Mottet (2000) shows that greater non-verbal interaction on the part of the instructor yields more positive student perceptions of his or her effectiveness, student/instructor relationships, and the distance learning format compared to traditional classroom environments.

Fewer studies have sought to clarify the impact of social presence on cognitive learning. In distance courses, a positive correlation has been shown between student performance and overall satisfaction, technological aspects of the course, and the rate of material exchange between student and instructor (all of which may contribute to social presence). An instructor's use of immediacy behaviors correlate with short-term recall (Kelly and Gorham, 1988) as well as cognitive learning and perceived learning (King and Witt, 2009); however, definitive studies on long-term cognitive learning are lacking and the relationship between social presence and knowledge acquisition in distance-learning courses remains unclear. Perhaps surprisingly, one study reported higher cognitive learning in a web-based psychology course compared to the traditional course, even though satisfaction with the distance learning environment was consistently lower (Carr, 2000).

B. The *Watersheds and Wetlands* Course

Stanford University's Civil and Environmental Engineering (CEE) 166A/266A, *Watersheds and Wetlands*, is an upper-level undergraduate/M.S.-level graduate course focusing on hydrologic processes taught by the second author (a professor at Stanford for whom English is the first language). It is intended as a relatively sophisticated introduction to hydrology for students with a solid background in fluid mechanics and quantitative analysis. The course is typically taught using twice-per-week class periods of 1 hour and 50 minutes duration. The primary media for presenting visual lecture materials are computer-based slideshows with paper handouts of the slides for each student, along with traditional blackboard/whiteboard techniques. Readings from a course text (Dingman, 2002) and other external sources supplement the lecture material. The students complete weekly exercises in which they are encouraged to collaborate using Excel or a similar data analysis package. Generally, at least one class hour per week centers on a discussion of the exercises (typically on the day they are due) during which time the instructor presents one or more possible solutions and the class discusses the methods and results.

This study was opportunistic, using data collected from three groups of students enrolled in the course during two separate years. In 2004, the course was offered for the first time as part of the Singapore Stanford Partnership in Environmental Science and Engineering (SSP). The program uses video conferencing classrooms, or "technology suites," that are located at Nanyang Technological University (NTU) in Singapore and at Stanford in the United States. They are specially equipped with professional-quality audio and video distance-learning technologies that allow synchronous communication between the two classrooms, including an audio and three real-time video feeds, and an interactive digital white board. During 2004, the instructor's primary location was at NTU, and 1 hour and 15 minutes lectures were given live at the NTU technology suite while a real-time broadcast was shown in the technology suite at Stanford. On two separate one-week occasions throughout the 10-week-long quarter, the instructor returned to the Stanford campus and the lecture process was reversed.

Regardless of the instructor's location, all class periods occurred in the early morning at NTU and in the late afternoon at Stanford. Two graduate teaching assistants (one based at NTU and the first author based at Stanford) were also involved in the course in 2004. Several modifications to the traditional course format were employed to accommodate the distance learning format required for the SSP program, including shorter class periods (75 minutes), nearly exclusive use of Microsoft PowerPoint for conveying lecture material, and a reduction in homework discussion sessions during scheduled lecture time. In addition, the instructor's office hours with the remote group of students (i.e., students at the opposite location from the instructor) were conducted for one hour twice a week via a real-time internet connection that allowed reciprocal, synchronous audio and video feeds of the instructor and student(s), as well as an interactive whiteboard that could be edited and viewed from both locations.

In 2005, the course was not offered through the SSP program; however, it was offered in the traditional format to students enrolled at Stanford. Data were collected from this group to acquire information about student perceptions of the course's technological components and educational climate under non-distance learning conditions. While the course was not offered in the same technology suite during this portion of the study, it was held in a lecture hall with a similar layout (tables arranged in concentric crescent rows facing the front of the lecture hall). The lecture hall differed from the technology suite in that extensive audiovisual equipment (video cameras, individual microphones, televisions, etc.) was not present. One graduate teaching assistant was involved and the course met in the mid-afternoon. Other than these differences, all other aspects of the course were held constant between 2004 and 2005. Both courses were taught by the same instructor and no major changes were made to the presentation slides, handouts, or the course syllabus.

The following classifications were used in this study to identify the three groups of participants: (1) the "remote" group of students in the 2004 distance course were located at Stanford and received the majority of their lectures via a real-time satellite connection while the instructor lectured live from NTU; (2) the "local" group of students in the 2004 distance course were located at NTU and received the majority of the lectures while the instructor was present in person at NTU; and (3) the group of students enrolled in the 2005 traditional-format course were Stanford students for whom all lectures were given by the instructor while present in person at Stanford with no distance component.

Year	Group	Type	Class Size	Time (hr)
2004	NTU^d	In Class	24	1.25
2004	SU^d	In Class	26	1.25
2005	SU^t	In Class	30	1.83
2005	SU^t	Out of Class	30	0.50

Table 1. Information used in calculating participation indices for the distance-format course in 2004 (denoted by ^{d}), or the 2005 traditional-format course (denoted by ^{t}). "In class" denotes participation during lecture. "Out of class" denotes participation during break (10 minutes) or after class (20 minutes).

III. Data Characterization and Collection

A. Characterizing Student Informants

All participants in this study were students who enrolled in the course without prior knowledge of the study and subsequently gave their informed consent to participate in the study. No alteration of the composition of the subject group through recruitment or denial of participation was attempted. All participants were adults above the age of 18.

During 2004, 50 students enrolled in the course: 24 M.S.-degree students at NTU in the SSP Program (the entire group of SSP students) and 26 students at Stanford—7 undergraduate, 16 M.S., and 3 Ph.D. The NTU student group was evenly split between men and women, and the majority of students were from China, India, or Singapore. They all had recently completed undergraduate degrees with majors in engineering or sciences. Sixty-five percent of Stanford students enrolled in the 2004 course were female. The majority of graduate students enrolled at Stanford were United States citizens affiliated with either the Environmental Fluid Mechanics and Hydrology (EFMH) or the Environmental Engineering Sciences (EES) programs of the Department of Civil and Environmental Engineering. The undergraduates were majoring in either Civil or Environmental Engineering or Earth Systems. In 2005, 30 students completed the course —8 undergraduate, 20 M.S., and 2 Ph.D., with similar academic preparation.

B. Logging Technological Difficulties

The frequency of occurrence of technological difficulties, such as audiovisual malfunctions, loss of satellite connection, and delays in beginning the lecture was recorded throughout the 2004 course. Video malfunctions included issues such as poor, frozen, or out-of-focus images. Audio malfunctions included brief pauses, delays, and poor quality of audio signals.

C. Recording Participation

Student participation during the class and interaction with the professor outside of class were directly measured. During each class period, student participation was categorized as either prompted or unprompted on the basis of whether the instructor specifically requested class participation (for example, by asking a question of the class). Interactions between the students and instructor during mid-class breaks and after class were also recorded for the Stanford students in the traditional course format in 2005; however, because the distance group did not have breaks during class, and because interaction with the professor after class at the Stanford location was precluded due to immediate termination of the video feed following the end of lecture, these interactions did not occur during 2004. Interactions were enumerated but not categorically binned as prompted or unprompted for this portion of the analysis. Participation data are reported as a participation index, which is the number of participation events in a given lecture normalized by the number of students in the class and the duration of the class in hours, multiplied by 100 (see Table 1 for values used in calculating the participation indices).

D. Student Perception Surveys

To assess student perceptions of the technologically-rich classroom environment and its impact on their learning experiences during the 2004 distance learning format, two surveys were developed and distributed to students on five occasions throughout the course. The "local survey" was designed to be administered to students following periods of time in which the instructor was present at their own location (i.e., lecturing live and in person), whereas the "remote survey" was designed for periods following the instructor's residence at the opposite location (i.e., lecturing via satellite). NTU students completed three "local" and one "remote" survey, while Stanford students completed one "local" survey and four "remote" surveys. Data presented from surveys when the instructor lectured from NTU have been averaged. Because only one survey was administered following the two lectures given during the instructor's visit to the Stanford campus (i.e., following lectures 5 and 6 when the local and remote surveys were reversed and given to the Stanford and NTU students, respectively), no average was taken. Comparisons were made within each student group to determine the effects of the instructor's location, but they were not done between groups.

Both surveys were intended to gauge student perceptions about the frequency and impact of specific events relating to the technology and distance learning format of the course. Using a four-point Likert scale, students chose from a set of evaluative statements (none, few, many, and very many) to rank the frequency of each event for the period of time prior to the survey but after the previous survey (typically 2–3 weeks). Survey responses of "many" and "very many" were grouped together for the purposes of analysis because student responses included the latter category in only a few cases.

Students assessed the impact that the event had on their learning experience using a five-point Likert scale with the evaluative statements very negative, negative, no impact, positive, or very positive. We did not attempt to define the evaluative statements when distributing the surveys; rather, the distinction was left to the individual students. Therefore, interpreting or ascribing differences between the responses of different students must be done with care.

A single survey was administered at the end of the 2005 traditional-format course. The first half of the survey included all applicable questions from the local and remote surveys given to the NTU and Stanford students during the 2004 course. The aim of the second part of the survey was to identify student opinions about the course format and methods of instruction, including course interactivity and technological requirements, through a series of subjective questions designed to elicit their personal opinions (rather than quantified estimates). In this way, we hoped to garner information about student perceptions of the class and its pedagogical efficacy as compared to (1) similar courses within the department, and (2) individual student preferences.

The number of students completing any of the surveys fluctuated depending on student absences. For Stanford, the sample size for surveys (computed as students completing at least 2 of the surveys) in 2004 was 25. The number of Stanford students completing any one of the remote surveys varied by at most 4 students (16 percent). The NTU sample size was 20, and the variability in students completing a local survey was at most 3 (15 percent). The survey of Stanford students from the 2005 traditional-format course represents a sample group of 18. The number of students completing each survey is summarized in Table 2. The sampling error differs for each survey question depending on the standard deviation of the sample responses and the sample size (number of participants). Survey responses are reported to the nearest 5 percent to encompass this variable uncertainty.

We note that certain aspects of this opportunistic study were not strictly controlled or optimized. For example, the class size for each of the three groups was small, year to year variations in classroom dynamics could not be controlled, and some data collection (e.g., certain surveys, see methods) could not be replicated due to logistical aspects of the course. These limitations precluded strict statistical interpretations of the data. Rather, we use data collected during this study to draw general conclusions about possible trends in distance learning and how instructors might address them in distance courses.

IV. Results and Discussion

In discussing data from the distance format course, we limit our analysis to comparing each student group to *itself* under both local and remote conditions. In other words, we compare Stanford student responses from when the instructor lectured from the remote versus local locations and we compare NTU student responses from when the instructor lectured from the remote versus local locations, but we do not compare NTU and Stanford responses to each other. However, because we did notice differences in how each group responded to the local and remote format, we include a discussion of the possible reasons for these differences. *The discussion of differences between NTU and Stanford responses should therefore be regarded as possible explanations that warrant further investigation rather than strict interpretations based on data.*

A. Student Characterization of the Traditional Course Format and Technology

Stanford students in the traditional-format course were asked to evaluate the course interactivity and technological requirements based on their personal preferences and similar courses they had taken (Figure 1). Based on their positive responses, Stanford students perceived that the amount of technology used in the course under traditional (non-distance learning) conditions was

Survey Type	Student Location	Instructor Location	Lecture Administered	Sample size (N)	Participants (n)
Local	NTU[d]	NTU	10	20	18
Local	NTU[d]	NTU	16	20	17
Local	NTU[d]	NTU	20	20	18
Remote	NTU[d]	SU	6	20	18
Remote	SU[d]	NTU	4	25	24
Remote	SU[d]	NTU	10	25	21
Remote	SU[d]	NTU	16	25	22
Remote	SU[d]	NTU	20	25	23
Local	SU[d]	SU	6	25	20
Traditional	SU[t]	SU	20	18	18

Table 2. Summary of student participation in the surveys. Two forms of the survey (local and remote) were given depending on the location of the instructor relative to the student group. The "lecture administered" column indicates the number of the lecture in which the survey was administered. Total sample size (N) reflects students completing at least 2 of the surveys throughout the distance-format course in 2004 (denoted by [d]), or the survey in the 2005 traditional-format course (denoted by [t]). The number of participants (n) is the number of students completing a specific survey.

appropriate and that the course format did not discourage participation or discussion.

B. Technological Difficulties

Figure 2 shows the timelines of various technological difficulties encountered during the 2004 course. The frequency of both video (Figure 2A) and audio (Figure 2B) difficulties was highest in the first seven lectures. Similarly, the duration of lecture time lost due to satellite difficulties during class (Figure 2C) and delayed start times due to satellite difficulties before class (Figure 2D) were higher in the first half of the course with no interruptions occurring toward the end of the quarter. This

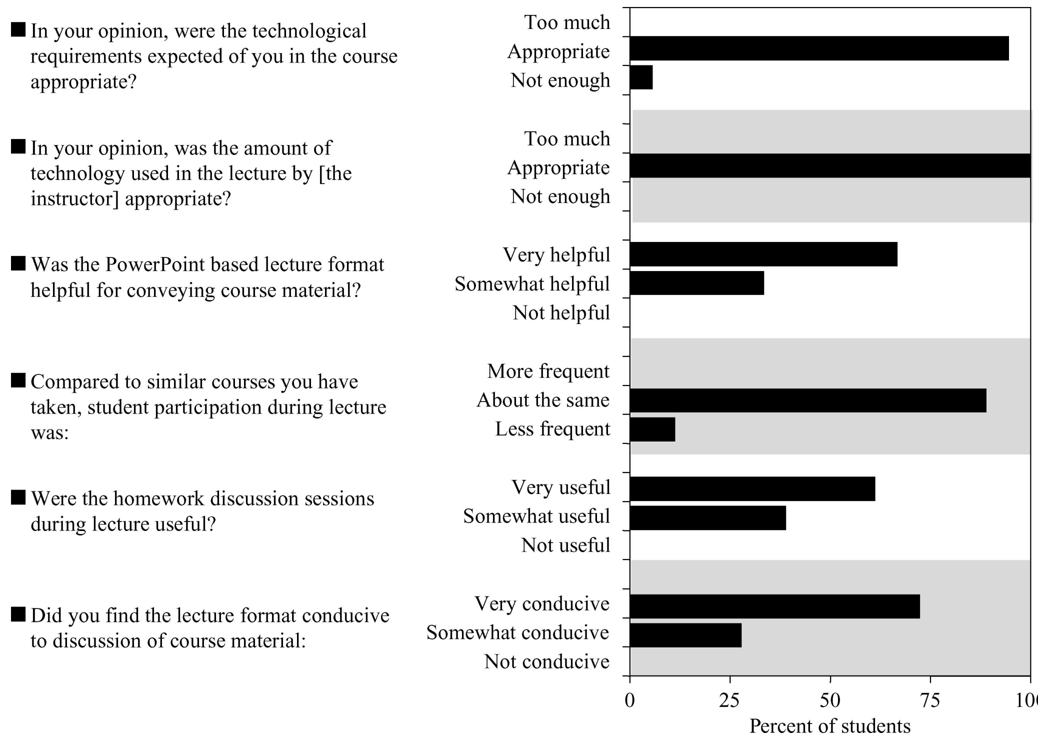

Figure 1. Student characterization of the course interactivity and technological requirements from survey data collected during the traditional course format in 2005. In general, students indicated the amount of technology and participation in the course was appropriate.

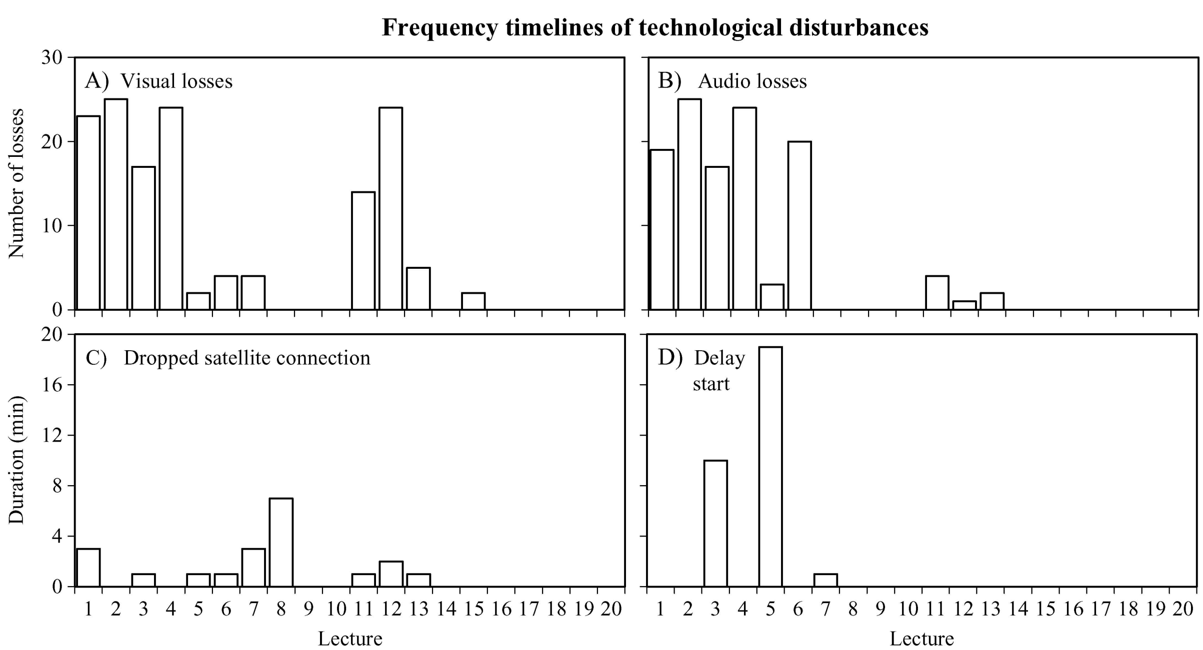

Figure 2. Timelines of technical disturbances throughout the course for (A) the number of visual losses, (B) the number of audio losses, (C) the duration of lost satellite connection, and (D) the duration of delay in starting class. Malfunctions were more frequent in the first half of the course.

pattern of difficulties influenced student satisfaction as discussed below.

C. Visual Disturbances

Both Stanford and NTU students indicated that visual issues named in the surveys (e.g., poor camera images, temporary video freezes, and the orientation of the instructor with respect to the camera) occurred during the distance format course. Temporary video losses were generally rated as having a more negative effect than flawed camera images (Table 3). Students were apparently better prepared to cope with continuously poor camera images (such as image contrails, delays, and blurred, poorly focused, and grainy images) than temporary losses in the video stream (which included the video "freezing" or cutting out entirely).

The homogeneity of responses about visual disturbances between Stanford and NTU students under local and remote conditions (Table 3) strongly indicates that normal amounts of motion and stillness by the instructor are not problematic for students in a distance learning course and that ordinary motion by the instructor is unlikely to strongly influence student perceptions of the class in a distance learning setting. This suggests that certain routine instructional movements like gesturing, writing on the whiteboard, and turning to face students when addressing, or being addressed should not impact student experiences in the class adversely.

D. Audio Disturbances

In contrast to visual disturbances, students in the distance course indicated that audio disturbances had a more negative impact on their learning experience. Audio losses led to decreased satisfaction even though students reported that audio losses did not necessarily lead to loss of information (Table 4). The lag time of audio devices, such as the microphones used for students to speak to the instructor, played a role in decreasing satisfaction. Participation was also impeded by these lags, likely because they disrupted normal conversational

Survey responses: Visual issues
Distance format group

Survey Question	Student Group Location	Instructor Location	Frequency of Occurrence			Impact on Learning Experience				
			None	Few	Many	Very Negative	Negative	No Impact	Positive	Very Positive
Camera did not provide good images	NTU[d]	SU	10	70	20	0	60	35	5	0
	SU[d]	NTU	10	80	10	0	40	55	5	0
Temporary video freezes	NTU[d]	SU	0	90	10	5	70	25	0	0
	SU[d]	NTU	14	70	20	5	55	35	5	0
Instructor did not regularly face the camera	NTU[d]	SU	80	20	0	0	0	90	5	5
	SU[d]	NTU	90	10	1	0	0	60	30	10
Instructor focused too much on the camera	NTU[d]	NTU	40	50	10	0	5	75	10	10
	SU[d]	SU	75	20	5	0	10	80	10	0
Instructor was too motionless	NTU[d]	NTU	75	25	0	0	5	65	15	15
	NTU[d]	SU	90	10	0	0	5	75	5	15
	SU[d]	NTU	95	5	0	0	0	65	20	14
	SU[d]	SU	90	10	0	0	5	65	20	10
Instructor moved too much	NTU[d]	NTU	55	45	0	0	0	75	10	15
	NTU[d]	SU	60	30	10	0	5	65	20	10
	SU[d]	NTU	86	15	0	0	0	65	25	10
	SU[d]	SU	100	0	0	0	0	70	20	10

Table 3. Visual disturbance survey data for NTU and Stanford students during the 2004 distance course (denoted by [d]). Both NTU and SU students indicated that temporary video losses had a greater negative effect on their learning experience than flawed camera images or instructor movement. Values are an average of all surveys collected throughout the course for each student group when "Instructor location" was NTU. All other values represent responses from only one survey. Values are given as percents (%).

Survey Question	Student Group Location	Instructor Location	Frequency of Occurrence: None	Frequency of Occurrence: Few	Frequency of Occurrence: Many	Impact on Learning Experience: Very Negative	Negative	No Impact	Positive	Very Positive
Remote group of students asked for material to be repeated due to technical errors	NTU[d]	NTU	45	45	10	0	15	60	15	10
	SU[d]	SU	15	80	5	5	20	45	20	10
Temporary audio losses	NTU[d]	SU	15	70	15	10	55	30	0	5
	SU[d]	NTU	20	60	20	10	50	35	5	0
My class did not ask for information to be repeated after audio losses	NTU[d]	SU	40	40	20	10	30	35	25	0
	SU[d]	NTU	50	30	20	0	35	55	10	0

Survey responses: Audio issues. Distance format group.

Table 4. Audio disturbance survey data for NTU and Stanford students during the 2004 distance course (denoted by [d]). Audio losses led to decreased satisfaction even though students reported that audio losses occurred less frequently than visual disturbances. Values are an average of all surveys collected throughout the course for each student group when "Instructor location" was NTU. All other values represent responses from only one survey. Values are given as percents (%).

cadence. The rhythm of a conversation is determined by an alternating pattern of speech and gaps and the duration of each gap constitutes a nonverbal cue for the listener. McLaughlin (1984) notes that gaps of different lengths help the listener interpret whether the speaker intends to continue speaking (as following a dramatic pause) or expects a response from the listener. Kalman and coworkers (2006) note that responsiveness and interactivity during conversation are closely linked and failure of the listener to respond or "to take the floor" creates a breakdown of interactivity. This conversational lapse, occurring when gap length exceeds only 3 seconds, has also been termed an "awkwardness limen" (McLaughlin and Cody, 1982). In other words, it is the threshold time beyond which participants perceive an awkward lapse in conversation. We suggest that by altering the timing of natural verbal communication patterns the audio lags introduced by the distance technology may have created an atmosphere in which both speaking and listening were perceived as awkward by the students. If this were the case, it could explain both the decreased student participation (see Figure 3, Table 6) and dissatisfaction with the audio aspects of the course (Table 4). Because awkwardly-paced conversation can still transmit information (facts), it follows that students indicated information was not lost as a result of these lags. Moreover, this suggestion is consistent with student reports that video losses caused them less disturbance than audio losses, because visual cues are secondary factors influencing the pace of naturally-occurring spoken communication.

E. Loss of Satellite Connection

Complete loss of satellite connection had a strong negative impact for both local and remote groups of students (Table 5) and generally caused suspension of class for approximately 5–15 minutes at both locations while the connection was re-established (Figure 2C). This highlights the importance of considering the potential effects of technology on students at the local location during synchronous distance education.

F. Student Participation

Student participation during the 2004 course was clearly influenced by two primary factors: (1) the progression of the course, and (2) the location of the instructor (Figure 3A,B). A sharply decreasing trend in participation was observed toward the latter half of the course for both Stanford and NTU students. Stanford students had more participation overall than NTU students, although participation was comparable between the groups for the first four lectures. We discuss possible reasons for these observations below.

For both Stanford and NTU students the most participation occurred when the instructor lectured at the Stanford campus (these lectures are denoted by an "X" on Figure 3A and B). Stanford student participation during these lectures exceeded all other days by at least two-fold (except for lecture 12 when the instructor was still at Stanford, but the lecture was delivered by a guest lecturer). NTU student participation was very low throughout the course, with 14 of the 19 lectures having no participation. Notably, the two lectures with the highest amount of participation from NTU students occurred when the instructor lectured to them remotely from the Stanford campus (Figure 3A and B).

Participation indices were much higher among the Stanford students enrolled in the traditional-format course in 2005 than in either group in 2004, and remained at this level as the course

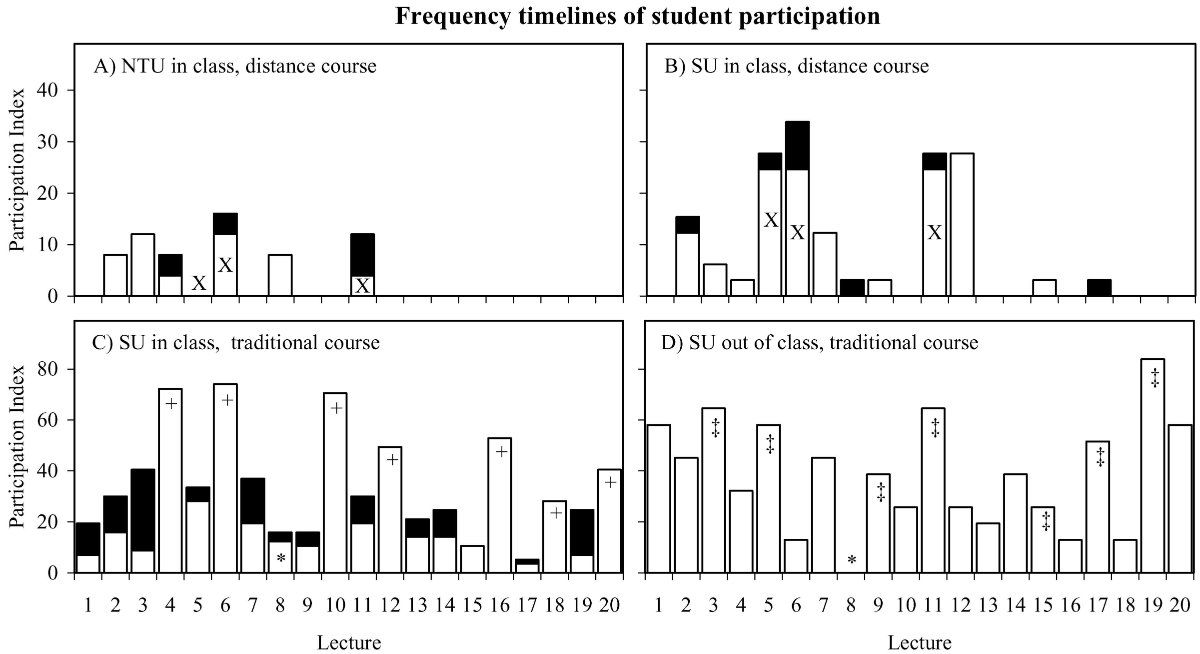

Figure 3. Timeline of participation indices (the number of participation events in a given lecture normalized by the number of students in the class and the duration of the class in hours, multiplied by 100) for (A) NTU students during class in the distance course, (B) Stanford students during class in the distance course, (C) Stanford students during class in the traditional course, and (D) Stanford students outside of class (during break, before or after class, etc.) in the traditional course. Shaded areas represent participation prompted by the instructor. An "X" denotes lectures delivered from the Stanford campus during the 2004 distance course; all others were delivered from NTU. In C and D, a "+" denotes lectures including homework discussion sessions; "‡" denotes days preceding a homework due date; and "" denotes a lecture ending 45 minutes early in the 2005 traditional course. Note that different scales are used for A and B and for C and D.*

Survey responses: Loss of satellite connection

Distance format group

Survey Question	Student Group Location	Instructor Location	Frequency of Occurrence: None	Frequency of Occurrence: Few	Frequency of Occurrence: Many	Impact on Learning Experience: Very Negative	Impact on Learning Experience: Negative	Impact on Learning Experience: No Impact	Impact on Learning Experience: Positive	Impact on Learning Experience: Very Positive
Complete losses of satellite connection	NTU[d]	NTU	20	65	15	15	40	40	0	5
	NTU[d]	SU	0	90	10	30	60	10	0	0
	SU[d]	NTU	25	70	5	20	40	30	10	0
	SU[d]	SU	0	100	0	5	65	25	0	5

Table 5. Loss of satellite connection survey data for NTU and Stanford students during the 2004 distance course (denoted by [d]). The strong negative impact reported by both NTU and SU students suggests that loss of satellite connection was a very important factor influencing satisfaction under both local and remote formats. Values are an average of all surveys collected throughout the course for each student group when "Instructor location" was NTU. All other values represent responses from only one survey. Values are given as percents (%).

progressed (Figure 3C). Other notable differences include periodic spikes in the participation index on days when homework was discussed in class (denoted by a "+" in Figure 3C.)

Participation during mid-class breaks and immediately following class by the Stanford students in the traditional-format course suggests that out-of-class interaction comprises a substantial portion of student-instructor interaction when the course is not in distance format (Figure 3D). The average participation index for out-of-class interaction was 41, as compared to the average in-class participation index of 35, indicating that students were as likely to communicate with the professor out of class as during class time. This is particularly evident for lecture periods preceding homework due dates (denoted by a "‡" in Figure 3D), when interaction was generally higher. Out-of-class communication is important in creating social presence

Survey Question	Student Group Location	Instructor Location	None	Few	Many	Very Negative	Negative	No Impact	Positive	Very Positive
			Frequency of Occurrence			**Impact on Learning Experience**				
I answered and/or asked questions	NTU^d	NTU	55	45	0	0	10	65	20	5
	NTU^d	SU	60	40	0	0	15	50	25	10
	SU^d	NTU	65	35	0	0	10	65	20	5
	SU^d	SU	55	35	10	0	5	50	45	0
	SU^t	SU	10	50	40	0	0	30	40	30
Other students at my location answered and/or asked questions	NTU^d	NTU	15	75	10	0	5	35	55	5
	NTU^d	SU	10	55	35	0	0	20	80	0
	SU^d	NTU	15	70	15	0	10	35	50	5
	SU^d	SU	0	35	65	0	0	20	65	15
	SU^t	SU	0	0	100	0	0	5	50	45
I had difficulty getting [instructor] attention	NTU^d	NTU	75	25	0	5	5	65	15	10
	NTU^d	SU	85	15	0	0	5	70	20	5
	SU^d	NTU	85	15	0	0	10	80	10	3
	SU^d	SU	100	0	0	0	0	70	30	0
	SU^t	SU	95	5	0	0	0	30	20	50
Students at my location had difficulty getting [instructor] attention	NTU^d	NTU	70	30	0	0	0	70	20	10
	NTU^d	SU	75	20	5	0	5	55	35	5
	SU^d	NTU	55	40	5	0	15	70	10	5
	SU^d	SU	100	0	0	0	0	65	35	0
	SU^t	SU	70	30	0	0	0	45	15	40
I felt intimidated asking and/or answering questions	NTU^d	NTU	62	36	2	0	10	65	15	10
	NTU^d	SU	65	30	5	0	40	35	20	5
	SU^d	NTU	60	35	5	5	30	60	5	0
	SU^d	SU	90	10	0	0	10	60	25	5
	SU^t	SU	45	35	20	0	35	25	20	20
[Instructor] did not ask for questions regularly	NTU^d	NTU	45	50	5	0	10	60	20	10
	NTU^d	SU	80	20	0	0	5	55	30	10
	SU^d	NTU	55	40	5	0	20	70	15	0
	SU^d	SU	75	20	5	0	0	65	30	5
	SU^t	SU	45	40	15	0	0	45	15	40

Survey responses: Class participation
Distance and traditional format groups

Table 6. Participation survey data for NTU and Stanford students during the 2004 distance course (denoted by ^{d}) and the group of Stanford students during the 2005 traditional course (denoted by ^{t}). In general, both NTU and SU students reported more participation occurred when the instructor was at the SU location. SU students reported that this had a greater positive impact, while NTU students reported no large impact on the learning experience. Values are an average of all surveys collected throughout the course for each student group when "Instructor location" was NTU. All other values represent responses from only one survey. Values are given as percents (%).

because personalized face-to-face communication (e.g., out-of-class conversations) offers students an opportunity to develop their sense of intimacy and immediacy. By contrast, when conversation is task oriented or more public (e.g., during class), the degree of social presence degrades (Tu and McIsaac, 2002). Out of class interaction may therefore increase student satisfaction with traditional format courses by improving social presence.

A set of five statements pertaining to participation were included in all surveys. The tabulated data for these survey questions are presented in Table 6 and possible implications of the responses are as follows.

1) Instructor location influences participation and satisfaction: Synchronous audiovisual technologies transmit many communication cues that contribute to social presence, such as gesturing, facial expression, and posture. However, some aspects of communication are lost through the distance learning technology, including eye contact and proximity, and this may diminish social presence. If a student perceives less social presence when an instructor lectures remotely, the student may be less likely to participate. Indeed, participation by Stanford students increased when the instructor was local (Figure 3) and led to greater satisfaction (Table 6) such that affective learning increased. Similar results were observed by Kearney, Plax, and Wendt-Wasco (1985) and Cristophel (1990), who noted that increased immediacy and social presence improved and facilitated affective learning.

In contrast, the NTU students did not report substantial changes in their learning experiences (Table 6) even though changes in their behavior were clearly noted in both the participation (Figure 3) and survey data (Table 6). This leads to two interesting implications. First, it indicates that the affective learning (satisfaction) of the NTU students was not strongly influenced by having the instructor present. Lower social presence therefore did not influence affective learning in this group of students to the same extent that it did the Stanford students (Table 6). This could suggest social presence has different functions for students from different backgrounds, and more work is needed to clarify if and how cultural differences affect the outcome of social presence on learning.

Second, the level of NTU student participation (but not satisfaction) during remote lectures was influenced by the level of in-class interactivity between Stanford students and the instructor. During these lectures, more instructor prompting (Figure 3) and more participation by the Stanford students (Figure 3) created a more conversational atmosphere that ultimately led to an increase in NTU student participation. The fact that this change in educational climate could be sensed by the NTU students at the remote location via the technological interface suggests that important communication factors were conveyed through the technological interface, possibly increasing social presence for some students.

The different responses of NTU and Stanford students to the instructor location may reflect differences in acclimation to the distance learning format and the educational climate with which each group was familiar. All NTU students in the SSP program were taking other distance learning courses in similar formats concurrently with this course, whereas many of the Stanford students had no familiarity with distance courses in which the instructor lectured from a remote location. Further, based on anecdotal accounts from the NTU students, a more formal lecture format with little interactive discussion is generally favored at their undergraduate institutions. Conversely, there is no such convention at Stanford and students are more likely to encounter, become familiar with, and potentially expect or favor discussion-based course formats. Stanford students may therefore have responded favorably to the greater amount of participation because it rendered the class format more familiar. In contrast, more instructor-prompted participation would not necessarily have generated a more familiar atmosphere for NTU students; hence more positive impacts were not reported by this group even though their participation increased.

2) Instructor prompting helps overcome technological barriers to participation: Stanford students in the distance course reported negative impacts when instructor-prompted participation was infrequent (Table 6). Together with the trends in recorded participation data (Figure 3), these results may indicate that prompting with questions is more important in courses taught in distance format where instructor-initiated interactions may improve student satisfaction by helping to compensate for lower unprompted student participation than in traditional formats.

Instructor-prompted participation may also be particularly important when course enrollees are not familiar with the distance-learning technology or when that technology is not easy to use. Stanford students reported decreased satisfaction when the instructor was at the remote location (Table 6); however, this was not the case for Stanford students when the instructor lectured locally at Stanford or for the traditional-format course (Table 6). This strongly suggests that difficulties with the technological interface led to decreased Stanford student participation and satisfaction during remote lectures. For example, in the technology suites there were no video cues to the instructor (at NTU) that a student was trying to participate at Stanford. Rather, all verbal student participation had to be spoken into microphones located at each student's desk, which required several seconds to become activated before transmitting the student's voice to the instructor. This apparently short delay often required the student to repeat the question several times, which was disruptive, especially if the instructor had already moved on to another topic and needed to be interrupted to hear the question. Students may have felt that the benefit of participating was outweighed by the amount of distraction or interruption and, therefore, may have opted not to participate. The steep decline in Stanford student participation during the second half of the course (Figure 3) supports this explanation and may have been the result of routinely encountering problems when asking a question or making a comment. Prompting by the instructor would help overcome this type of barrier in distance courses.

G. Cognitive Learning

Cognitive learning was explored quantitatively using student scores on homework assignments and exams. Raw scores on student work were not adjusted for relative performance (i.e., curved) allowing direct comparison among the groups. Cumulative end-of-quarter grade distributions were statistically similar for NTU and Stanford students in 2004 ($p < 0.05$, Figure 4, Table 7), and no significant difference was found between the cumulative end-of-quarter grade distributions of the traditional-format group of Stanford students in 2005 with either the NTU or Stanford groups in 2004. These results suggest that cognitive learning was not significantly different between the remote and local distance course formats, or between traditional and distance course formats.

The link between affective learning and interaction is well established for distance learning environments and our results agree with previous studies. We show that factors which diminish social presence (e.g., loss of immediacy due to poor audio quality and infrequent

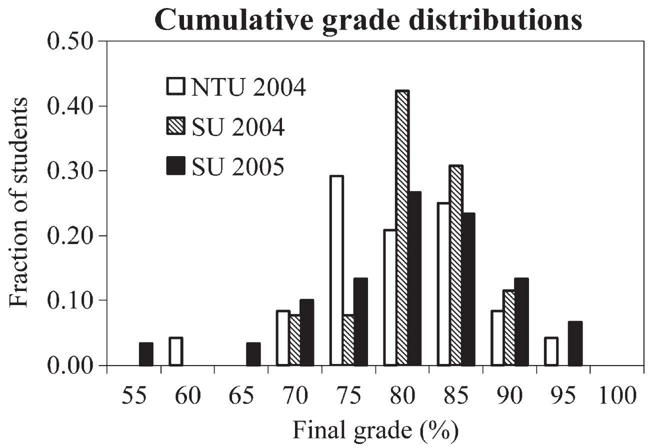

Figure 4. End of quarter grade distributions for NTU and Stanford students during the 2004 distance course and for Stanford students during the 2005 traditional course. Distributions were similar for all three groups, suggesting that student cognitive learning was not affected in the distance format course relative to the traditional format course.

	NTU 2004	SU 2004	SU 2005
minimum	58	67	51
maximum	94	90	92
mean	77	79	78
SD	8	5	9
n	24	26	30
median	76	78	79

Table 7. Cognitive learning score statistics for NTU and Stanford students during the 2004 distance course and the group of Stanford students during the 2005 traditional course show no significant differences among the groups ($p < 0.05$). Values are given as percents. SD is the standard deviation of the scores, n is the number of students.

student-instructor verbal interaction in and out of class) lead to reduced student satisfaction (Gunawardena and Zittle, 1997). However, the relationship between social presence and knowledge acquisition in distance learning courses is less clear. Our results show that indicators of cognitive learning were not different in traditional and distance course formats, despite marked differences in affective learning. These results are similar to those of Carr (2000), where satisfaction was lower and cognitive learning was higher in a distance course compared to a traditional course. Affective learning therefore may not be a robust indicator of cognitive learning in distance course environments. The uncoupling of affective and cognitive learning reported here hints at the complexity and flexibility of learning processes; when affective learning is diminished, students may devise alternative strategies that allow them to achieve levels of knowledge acquisition comparable to or greater than when affective learning is unimpeded. These strategies could include greater reliance on independent study, peers, or teaching assistants, all of which could potentially improve cognitive learning while not necessarily altering student satisfaction with the course.

V. Conclusions and Recommendations

The goal of this study was to identify important aspects of a synchronous distance learning engineering course that influenced affective and cognitive learning. We identified several important factors influencing student satisfaction (affective learning). We also found that establishing a high degree of social presence in distance courses may foster learning strategies that are more similar to traditional course formats and, hence, more familiar to students. Therefore, while our findings do not suggest cognitive learning is strongly affected by social presence, implementing strategies to enhance social presence may improve the overall learning experience and make the distance learning environment more enjoyable for students. The major findings of this study are summarized below, along with strategies that appear to be effective for facilitating social presence in distance learning environments.

1. In-class interaction between students and the instructor increases satisfaction in distance-learning environments for some groups of students. In-class participation should be encouraged through instructor-prompted discussions, which may serve to ameliorate intimidation stemming from lack of familiarity with the technology.
2. In-class interaction may be a less important factor influencing satisfaction for students who are accustomed to educational climates where in-class participation is not common.
3. Out-of-class interaction may constitute a substantial portion of the total interaction between students and the instructor under traditional course formats. Whenever possible, out-of-class interaction should be encouraged in distance courses in order to increase instructor immediacy.
4. Audio difficulties and loss of satellite connection that cause delays in class appear to have a greater impact on student satisfaction than do visual difficulties. Accordingly, as distance learning technologies continue to evolve special consideration should be given to improving the clarity and reliability of audio equipment and the satellite transmission systems.
5. Cognitive learning does not appear to increase or decrease with social presence or affective learning of students; however, efforts to encourage social presence may create a more positive learning experience for students in distance courses. More work is needed to identify the factors influencing cognitive learning in distance courses, as well as to clarify the role of social presence, if any, in cognitive learning.

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