Evaluating Interactivity and Presence in an Online Distance Learning System

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***Abstract* - A new online distance learning system was created by an interdisciplinary team comprised of computer science, graphics, networking, security, and educational science faculty and graduate students to research, implement, and assess the ability to extend a face-to-face classroom to accommodate remotely located students. Comprised of a face-to-face classroom setting with remote students' images projected on the wall of the classroom, this "virtual classroom" is a 3-D rendering of a geometric model populated with real-time video avatars of remote students. Through increased presence, (i.e. being able to view remote students' facial expressions, general body language) and better integration of the virtual classroom into the local classroom, developers intended to increase both learning and motivation to learn. In a formative evaluation regarding the "presence" and "interactivity" afforded by the system, the following elements were analyzed: learning; social, cognitive, and physical presence; student-to-content interaction; and student-to-technology interaction. This paper reports on this new distance learning technology and the evaluation used to assess its effectiveness.**

Index Terms – Evaluation, Interaction, Online distance learning, Presence, Virtual environment.

BACKGROUND

The creation of a new online distance learning system was funded by an NSF grant in 2004. Key contributions of this work are to produce a prototype system that will have a better sense of presence and a higher degree of interactivity than existing systems. The technical goal was for remote students to be integrated into a virtual extension of the classroom, which is projected onto the back wall of the classroom (see Figure 1).

FIGURE 1
DISTANCE EDUCATION SYSTEM DEPLOYED IN FIRST CLASSROOM

A remote student is acquired with a webcam and is modeled as a real-time video avatar, thereby removing the background of remote students. Even though each remote student can potentially be located at a different site, the remote students are integrated into a unified virtual environment, which is displayed at a natural location within the field of view of the instructor. The instructor gets a sense of the body language and facial expression of remote students and sees if a remote student raises his/her hand in real time (see Figure 2).

FIGURE 2
PHOTOGRAPHS OF THE BACK-WALL SCREEN SHOWING REMOTE STUDENTS INTEGRATED INTO A VIRTUAL EXTENSION OF THE CLASSROOM

Audio is captured continually for each remote student and played in the classroom. Instructor audio and video is continually provided to each remote student. This system strives to make distance education an integral but unobtrusive part of conventional on-campus education. This is achieved by relying almost exclusively on commodity components.

The instructional goals are to increase learning and motivation to learn within a distance learning environment. The intention was to provide a distance learning system that would improve the quality of distance learning by equaling the effectiveness of a conventional, on-campus course in the area of student learning. Through an increased sense of presence, such as being able to view facial expressions of remote students, general body language, etc, and better integration of the virtual classroom into the local classroom, the developers intended to increase both student learning and motivation to learn. The purpose of the evaluation of this system was to evaluate the "presence" and "interactivity" afforded by the system. Because we were not doing a comparative evaluation, we did not, for example, evaluate the effects of subtracting background, versus not subtracting background on learners' sense of presence and interactivity.

For readers interested in related evaluated efforts of distance learning see Anderson, Beavers, VanDeGrift, and Videon [1], Kabat and Friedel [2], or Sowa and Hirano [3].

OPERATIONALIZING VARIABLES OF INTEREST

The first step in the evaluation was to determine the qualities or attributes to be measured. Aspects of presence and interaction were identified that impact learning in an online distance learning system. This was accomplished by reviewing literature on presence and interaction in terms of their impacts on a) motivation to learn, and b) learning in distance learning systems. Through this review, the evaluators identified the following three aspects of presence: social presence, cognitive presence, and physical presence. The evaluators also classified interaction into different categories: student-to-student, student-to-instructor, student-to-content, as well as student-/instructor-to-technology interaction. The following sections briefly discuss presence and interaction respectively.

I. Social Presence

Social presence in one aspect "…involves the degree to which media are capable of making users perceive other users' sociability, warmth, sensitivity, personality, or closeness in a mediated communication situation" [4,p.124]. A high degree of social presence means that participants will have a "sense of being in and belonging in a course and the ability to interact with other students and an instructor although physical contact is not available" [4,p.22]. As for the evaluation purpose of this distance learning system, the evaluators mainly examined the students (both from local and remote sites) and the instructor on how well they ***perceived*** they were belonging in the same class.

II. Cognitive Presence

Cognitive presence refers to one's cognitive processes orientated toward another world or tasks with the focus of attention to the related proximal stimulus, "either technologically mediated or imaginary, to such an extent that he or she experiences mentally the state of being (there)" [5,p.524]. A user needs to feel cognitively oriented to a system, so that any content being presented is receivable. For this study, the evaluators focused on the technologically mediated cognitive effect of the system. The evaluators sought to find out whether the learners felt cognitively present to tasks and experienced mentally the state of "being there" in the distance learning system. The evaluators also sought to determine if cognitive presence had an impact on learning within this distance learning system.

III. Physical Presence

Researchers often distinguish between physical presence and social presence. "Physical presence implies being present in (or present to) the virtual or real environment: being there" [6,p.341]. Users of the virtual system should feel like they are in a real-life physical environment as opposed to a virtual environment. For the purpose of this evaluation, the evaluators examined how well the system increased the learners' perceptions of presence. It should be pointed out that cognitive and physical presence affect social presence in a distance learning system. Virtual environments are designed to "give the user a type of mediated experience that has never been possible before: one that seems truly "natural," "immediate," "direct," and "real," a mediated experience that seems very much like it is not mediated; a mediated experience that creates for the user a strong sense of presence" [7]. This is considered the 'realness' of the virtual environment.

IV. Interactivity

A sense of presence can be achieved if the system is interactive and highly responsive in a many-to-many context communication [8]. In literature, interactivity is viewed as one of the dimensions of presence [9] and, therefore, interaction and presence intertwine in distance learning. The evaluators used four major categories: student-to-student; student-to-instructor, student-to-content, and student-to-technology. However, because the system functionality did not allow much interaction, it was decided to postpone the evaluation of student-to-student and student-to-instructor interactivity. Results are only reported on student-to-content and student-to-technology interaction.

V. Student-to-Content Interaction

As Northrop [10] described, "content interaction is based on the theory of learning that is most appropriate to achieve educational outcomes within the course itself" [10,p.32]. Northrop also stated "the instructional content is the central component of a web-based course as this is where new knowledge, skills, and abilities are presented" [10,p.34]. Without interaction between learner and content, there cannot be education since the point is to provide new content to learners [11]. The evaluators looked at different available

tools/functionalities and their impact on instruction and learning in this system.

VI. Student-to-Technology Interaction

There is also interactivity between the participants (students and instructor) involved in an online distance learning course and the technology being used. Both students and instructors "need time to adjust to new technology" [12,p.101]. The bottom line is that the students and instructor should not feel any discomfort while using the system. For this aspect, the evaluators examined if there were any physical discomforts for the users while using the system and how well the learners adjusted to the system.

The evaluators used the relative literature and resources of presence and interaction in distance learning to form aspects and categories of presence and interaction they believed were critical and essential to an effective distance learning system. Based on these attributes, the evaluators developed instruments to measure the degree to which these attributes were manifest and perceivable, thereby indicating the degree or level of these attributes within the system.

METHODOLOGY

I. Nature of the Evaluation

Once the variables of interest had been defined, the nature of the evaluation was articulated. It was determined that the nature of the evaluation was a formative evaluation. Formative evaluation is designed to "collect data and information that is used to improve a program or a product" [13,p.374]. A typical formative evaluation involves one-on-one, small group, and/or field trial evaluations conducted directly with learners [13]. For each, the evaluators spent time with the learners, observing and interviewing the learners, and trying to understand the nature of problems encountered when using the system. In summer 2006, a field trial, referred to as a pilot study, was conducted, which involved eight learners.

II. Pilot Study

The pilot study investigated the degree to which the system supported social, cognitive, and physical presence, student-to-content interaction, and student-to-technology interaction and the impact on learning of these variables. Some of the more specific questions for each of these independent variables are listed below.

The questions for social, cognitive and physical presence are:

- Does the system support social, cognitive, and/or physical presence?
- To what degree does the system support social, cognitive, and physical presence?
- To what degree do the students and instructor feel like being with someone virtually feel like being with them locally?
- To what degree does the system support students and instructors feeling as if they are in (or present to) the virtual or real environment? (Being there)
- To what degree do students and instructors feel a "realness" of the virtual environment?
- To what degree does the system support students and instructors feeling that virtual **people** look and sound as if they are real when they are perceived through the system?

The questions for student-to-content interaction and student-to-technology interaction are:

- Does the system support student-to-content interaction and to what degree?
- What is the impact of the current state of uninterrupted communication on student learning and motivation to learn?
- Does the system cause the users any physical discomfort? If yes, why/how? To what degree?

To test the dependent variable three hypotheses were developed as follows:

- Hypothesis one: There is no significant difference between the means of the pretest scores for local and remote participants.
- Hypothesis two: There is a significant difference between the means of the posttest scores for local and remote participants.
- Hypothesis three: There is a significant difference between the means of the overall pretest scores and the overall posttest scores.

III. Evaluation Design

The next step of this evaluation was to identify the overall evaluation design for a pilot study. This pilot study was an exploratory study with the purpose of 1) locating weaknesses of the distance learning system and 2) investigating the impact on student learning. A descriptive research methodology utilizing observation, interview, and survey was adopted for this pilot study. A descriptive method describes and interprets the phenomenon being studied. This method focuses on the opinions of the people, processes/trends that are occurring, and the evidence of the effects in the studied setting [14]. Because of the scale of this pilot study and the purpose of this formative evaluation, the evaluators chose to collect more in-depth (meaning personal opinions and perception) data from a small group of learners.

Eight voluntary, adult learners were recruited for the pilot evaluation study. The evaluators attempted to create groups that were balanced on motivation to learn and ability level in order to control for these intervening variables. An equivalent forms pre-post test design was used to measure learning. After selecting the ideal participants from the available pool, the eight learners were assigned to the two learner groups: 1) local and 2) remote.

The local site in the distance learning system was chosen by one of the faculty designers who had access to a suitable classroom, which was set up as the local site for the distance learning instruction. The remote sites were chosen in a similar manner. The planned instruction for this formative evaluation was a series of 4 mini lectures on Digital Video each 45

minutes long. The subject content involved and elicited group discussion, group interaction, collaboration, and cooperation.

The final step in this evaluation was to create a data collection framework. The evaluators determined which data collection tools would be able to best supply answers to the list of questions. The data collection instruments chosen were focus groups, surveys, standardized open-ended interviews, design review, and non-participant observation. Readers interested in a copy of the survey instrument are invited to contact the primary author.

Some questions were answered by more than one data collection instrument. Multiple data sources were used to enhance the validity of the data.

RESULTS

An equivalent forms pre-posttest was used to measure learning. Table I presents the results for all eight participants.

TABLE I
PRETEST AND POSTTEST STATISTICS

Variable	N	Mean	Std Dev	Min	Max
All Pretest	8	2.75	2.43	0	6
All Posttest	8	9.375	1.85	6	12
All Difference	8	6.625	3.34	3	12
Local Pretest	4	3.25	3.20	0	6
Local Posttest	4	8.25	1.71	6	10
Local Difference	4	5	3.16	2	9
Remote Pretest	4	2.25	1.71	0	4
Remote Posttest	4	10.5	1.29	9	12
Remote Difference	4	8.25	2.99	5	12

I. Pretest/Posttest Results

Hypothesis one stated that there is no significant difference between the means of the pretest scores for local and remote participants tested at the P=0.05 level. A paired-samples t-test was conducted to determine if the difference between local pretests and remote pretests was significant. The mean rating for local pretests (M = 3.25, SD = 3.2016) was not significantly different (t = 0.42, df = 3, P = 0.702697) from the mean rating for remote pretests (M = 2.25, SD = 1.7078) suggesting that both sets of learners had equal content knowledge prior to the course.

Hypothesis two stated that there is a significant difference between the means of the posttest scores for local and remote participants. A paired-samples t-test was conducted to determine if the difference between local posttests and remote posttests was significant. The mean rating for local posttests (M = 8.25, SD = 1.7078) was not significantly different (t = -3, df = 3, P = 0.057669) from the mean rating for remote posttests (M = 10.5, SD = 1.291) suggesting that both sets of learners had equal content knowledge after the course.

Hypothesis three stated that there is a significant difference between the means of the overall pretest scores and the overall posttest scores. A paired-samples t-test was conducted to determine if the difference between overall posttests and overall pretests was significant. The mean rating for overall posttests (M = 9.375, SD = 1.85) was significantly higher (t = -5.62, df = 7, P = 0.000801) from the mean rating for overall pretests (M = 2.75, SD = 2.43) suggesting that students had more knowledge of the course content at the end than at the beginning.

This suggests that all learners experienced knowledge gain and that the remote students learned as much as the local students.

II. Survey Results

To evaluate the system's support of social presence, nine survey questions were asked. On the majority of the questions, the local students perceived the social presence more favorably than the remote students. The remote students could hear and see the instructor, but could only hear the local students and the other remote students. Thus, remote students basically were working with one modality, audio; whereas the local students had two different types of interactions, both auditory and visual. Local students could see other local students sitting next to them, or remote students' digitized images. The evaluators believe this is the most significant reason for the differences in perceptions of social presence between remote and local students.

However, two of the questions remote students rated more favorably stand out. Two of the five questions inquiring to what degree the students felt like being with someone virtually felt like being with them locally, the remote students rated more favorably. "Even though we were not physically together in a traditional classroom, I still felt like I was part of a group in the online course" and "The instructor was often aware of me in the room". An observer noted that although all the local students had nameplates, the instructor did not call on the local students by name. He did, however, call on the remote students by name. This could explain the remote students' perceptions that the instructor was aware of them in the room.

In order to evaluate the system's support of cognitive presence, 18 survey questions were asked. The local students perceived cognitive presence more favorably than remote students in this system. However, a few individual questions were answered more favorably by remote than local students. In response to the question, "To what extent were there times, if at all, during which the computer interface seemed to vanish, and you were directly working with the other students" the remote students perceived this more favorably than local students. Remote students also felt less like they were "just perceiving pictures" than the local students. This might be explained since the remote students were watching a live video feed of the instructor moving around; whereas the local students were seeing a picture of the remote students sitting at a desk, and when sitting at a desk most students do not move around very much. So although they were live feeds, they were more like still photos than video. The remote students also felt more positively than local students about "How compelling was your sense of other participants being present". This could be explained by the remote students using headphones to hear every student's (local and remote) responses to each other and the instructor; whereas the local students might have "tuned out" other students talking because it wasn't being fed directly into their ears through headphones.

These are interesting results as they suggest that technology might actually be able to improve sense of presence.

In order to evaluate the system's support of physical presence, 13 questions were asked. Again local students rated questions about the system more favorably except in two areas. When asked if the virtual world seemed like a place the students "saw" or a place they "visited", more remote than local students rated the system as a place they visited indicating a higher sense of presence. Remote students also had an overall higher sense of being in a virtual classroom with other students when compared to the ratings of the local students.

A four-way comparison was done with two physical presence questions: how local students felt with other local students, how local students felt with remote students, how remote students felt with local students, and how remote students felt with other remote students. Two questions were posed to both categories of students: "To what extent did you have a sense of being in the same room as the students in the remote classrooms" and "To what extent did you have a sense of being in the same room as the students in the local classroom". As expected, local students rated being in the same room as other local students with 100% favorability since they were physically in the same room. Interestingly, the local students rated being in the same room as remote students as a 10/20, whereas remote students rated being in the same room as local students as a 7/20. This suggests that the digital avatars of remote students being projected on the back wall of the classroom impacted students' sense of physical presence. The challenge will be to ensure the remote students feel as present as the local students.

In order to evaluate the system's support of "realness", 14 questions were asked. Four questions inquired to what degree students felt a "realness" of the virtual environment. Three questions inquired to what degree the system supported students feeling that virtual things looked and sounded as if they were real when they were perceived through the system. Four questions inquired to what degree the system supported students feeling that virtual people looked and sounded as if they were real when they were perceived through the system. Two questions inquired to what degree the system supported students feeling that virtual events looked and sounded as if they were real when they were perceived through the system.

The most notable difference in the way remote students responded was to the following question: "To what extent did the virtual classroom experience lack emotions". The remote students ranked the question much more favorably than the local students; meaning that the local students perceived the virtual classroom lacked emotions more than the remote students perceived. This was a surprising result seeing as how the remote students had fewer modes of interaction than the local students.

In order to evaluate the system's support of student-to-content interaction, 18 questions were asked. Local students rated the majority of the student-to-content interaction questions more favorably than the remote students. Three of the local students felt there was "no change" in student-to-content interaction, while one local student felt their interaction "decreased". For remote students, two students felt their interaction "somewhat increased" and the other two felt their interaction "somewhat decreased".

In order to evaluate the system's support of student-to-technology interaction, 27 questions were asked. Interestingly, when answering the question, "When did you feel that the instructor noticed your raised hand" the remote students perceived that the instructor noticed their raised hands more than the local students perceived. However, one local student did not answer this question, possibly because they never raised their hand. This may skew results to this question. In response to this question: "During the course, you had the opportunities to experience the virtual hand raising, two-way video conversation with instructor and other students, downloading the course documents, etc, did the speed of these features have an impact on your motivation to learn", remote students felt that the speed has less impact than the local students on their motivation to learn. Perhaps this is because when using technology, we get used to the speed slowing down and glitches along the way, but in a face-to-face course, we expect more immediate gratification.

DISCUSSION AND IMPLICATIONS

The evaluators also compared local vs. remote students' perceptions of social, cognitive, and physical presence, realness, and student-to-content (SCI) and student-to-technology (STI) interaction (Table II).

TABLE II
AGGREGATE SURVEY RESULTS

Variable	Social Presence	Cognitive Presence	Physical Presence	Realness	SCI	STI
Local	68.30%	71.10%	70.30%	63.80%	55.80%	47.60%
Remote	68.40%	59.10%	51.90%	55.70%	51.90%	49.70%

It is interesting to note that local students rated social presence third in a rank order list and remote students ranked it first. However, looking only at the percentage points, the local students scoring for social presence (68.33%) is still higher than the remote students scoring for social presence (64.44%). This is just one indication that local students generally had a more favorable impression of the system than did the remote students. This is not surprising; as previously noted, local students were able to see and hear the local students. The two modalities likely did create a more complete sense of presence. In order for the remote students to feel more present, the system will need to support 1) two way video, where remote students can see local and other remote students, including themselves, as well as 2) two way audio where remote students can hear local students (they can already hear each other). Other suggestions include 1) having a camera that is sensitive enough to pick up natural movements - for example, remote students had to exaggerate their head nodding in order for it to be detected by the instructor, 2) fix the audio lag and 3) allow remote students a

wider range of motion - they commented that sitting in the same position was unnatural.

Despite student perceptions, both groups scored roughly the same on the posttest, which suggests that current functionality is as efficacious for remote students as it is for local students when the primary mode of delivery is lecture. Delivering content through lecture is primarily used when the content to be learned is at the level of factual recall and/or conceptual understanding. However, often the goal of instruction is for learners to acquire deeper understanding or abstraction, such as application of principles, methods and procedures, critical analysis of patterns and cause/effect relationships, or synthesis of knowledge to generalize to novel contexts. These deeper levels of thinking often require more interactivity, e.g., more active participation in learning by the learners, more communication and different modes of communication, and increased collaboration in a wider variety of roles. Therefore, an important line of inquiry is system functionality and effectiveness when an instructor wants to promote deeper learning through more interactivity? There are several questions worth asking, including, but not limited to the following. What is the influence of the functionality of the systems on perceptions of social, cognitive, and physical presence and the consequent influence on learning? Are there systematic differences between remote and local learners' perceptions of presence and learning? Are the aspects of presence (social, cognitive, physical) and interactivity (student-to-student, student-to-instructor, student-to-content, and student-to-technology) related to levels of learning (factual recall, conceptual understanding, application, analysis, synthesis) and if so, how? Questions such as these are important next steps in this work as they can contribute both to fundamental understanding of learning as well as to the design of systems to support learning at a distance.

ACKNOWLEDGMENTS

Support for this work was received from the National Science Foundation, SCI-0417458. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We would also like to acknowledge the following contributors to this project: Laura Arns, Carlos Morales, Brandon Sorge, Dazhi Yang, Radu Dondera, and Chun Jia.

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